A 2-Day Course at GMI

# Research Methodology

## Module 1

## Overview of Research and its Methodologies

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# Course Objectives

At the end of this course, the students should be able to:

- understand some basic concepts of research and its methodologies
- identify appropriate research topics
- select and define appropriate research problem and parameters
- prepare a project proposal (to undertake a project)
- organize and conduct research (advanced project) in a more appropriate manner
- write a research report and thesis
- write a research proposal (grants)

## What you will not get!

Instant Expertise!

" Expertise is earned – not given"

**"Geniuses are made– not [illegible]e"**

## *Course Outline*

Module 1:

[1] Overview of Research and its Methodologies

- 1.1: Concepts of research
- 1.2: The need for research
- 1.3: Types of research
- 1.4: Steps in conducting research

## Module 2:

### [2] Literature review

- 2.1: What is literature review?
- 2.2: Why the need for literature review?
- 2.3: How to carry out a literature review?

### [3] Selecting and defining a research problem

- 3.1: Problem formulation – why the need for this?
- 3.2: What are the criteria for selecting a problem?
- 3.3: Identifying variables
- 3.4: Evaluating problems
- 3.5: Functions of a hypothesis

## Module 3:

### [4] Conducting the research

- 4.1: Research activities
- 4.2: Preparations before conducting your research

### [5] Examples of Research at the University

- 5.1: Differences among Postgraduate and Undergraduate Research
- 5.2: Research at the postgraduate level (PhD and MSc)
- 5.3: Research at the undergraduate level (BSc)
- 5.4: Preparations for an Undergraduate Final Year Project

Module 4:

[6] Writing Research Reports and Thesis

- 6.1: Why the need to write papers and reports?
- 6.2: Writing a research report
- 6.3: Writing a technical paper
- 6.4: Contents of a thesis

[7] Writing Research Proposals

- 7.1: Why do we need to write research proposals?
- 7.2: Research Grants in Malaysia
- 7.3: How to write Good Research Proposals?
- 7.4: Case Study

# *Research Methodology*

[1] Overview of Research and its Methodologies

1.1: Concepts of Research
1.2: The need for research
1.3: Types of research
1.4: Steps in conducting research

## 1.1 Concepts of Research

# What is research?

# Which of these can be classified as research?

- [1] Encik Samad prepared a paper on "computer usage in secondary schools" after reviewing literature on the subject available in his university library and called it a piece of research.
- [2] Encik Muthu says that he has researched and completed a document which gives information about the age of his students, their SPM results, their parents income and distance of their schools from the District Office.
- [3] Encik Lim participated in a workshop on curriculum development and prepared what he calls, a research report on the curriculum for building technicians. He did this through a literature survey on the subject and by discussing with the participants of the workshop.

None of the above examples
can be classified under the name research.

WHY ?

You will know it when you have understood

the concept of the term ‘research’.

## Consider the following case which is an example of research:

- A general manager of a car producing company was concerned with the complaints received from the car users that the car they produce have some problems with rating sound at the dash board and the rear passenger seat after few thousand kilometers of driving.
- He obtained information from the company workers to identify the various factors influencing the problem.
- He then formulated the problem and generated guesses (hypotheses).
- He constructed a checklist and obtained requisite information from a representative sample of cars.
- He analyzed the data thus collected, interpreted the results in the light of his hypotheses and reached conclusions.

- You will notice in the example above that the researcher went through a sequence of steps which were in order and thus systematic.
- Secondly, the researcher did not just jump at the conclusions, but used a scientific method of inquiry in reaching at conclusions.
- The two important characteristics of research are : it is systematic and secondly it follows a scientific method of enquiry.

## Definition of Research

- Hunting for facts or truth about a subject
- Organized scientific investigation to solve problems, test hypotheses, develop or invent new products

# What is Research?

Research is systematic, because it follows certain steps that are logical in order. These steps are:

- Understanding the nature of problem to be studied and identifying the related area of knowledge.
- Reviewing literature to understand how others have approached or dealt with the problem.
- Collecting data in an organized and controlled manner so as to arrive at valid decisions.
- Analyzing data appropriate to the problem.
- Drawing conclusions and making generalizations.

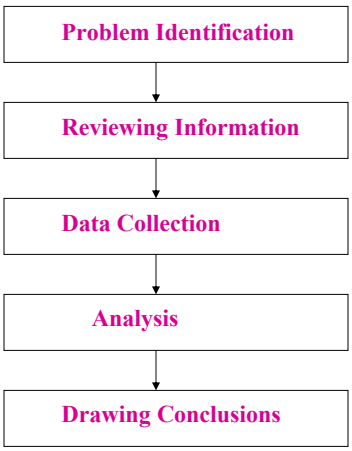
# High Quality Research!

- It is based on the work of others.
- It can be replicated (duplicated).
- It is generalizable to other settings.
- It is based on some logical rationale and tied to theory.
- It is doable!
- It generates new questions or is cyclical in nature.
- It is incremental.
- It is apolitical activity that should be undertaken for the betterment of society.

## Then, what is bad research?

- The opposites of what have been discussed.
- Looking for something when it simply is not to be found.
- Plagiarizing other people's work.
- Falsifying data to prove a point.
- Misrepresenting information and misleading participants.

- This general systematic characteristic of research is illustrated below.



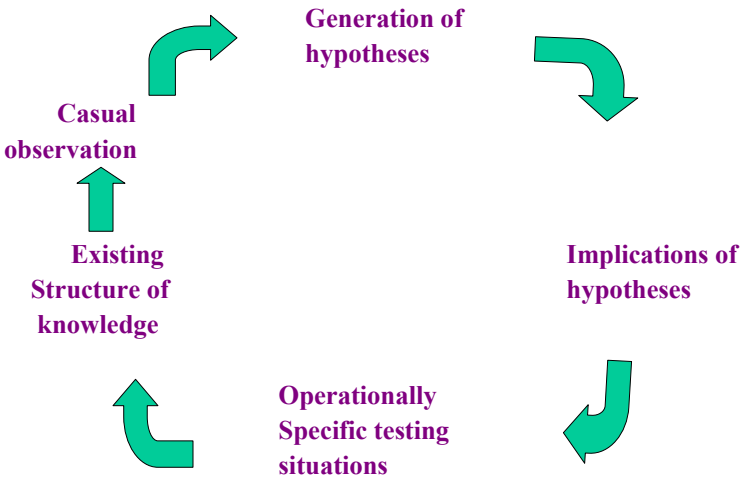

Schematic Characteristic of Research

## What is Research?

- Research follows a scientific method.
- This means that it makes an integrated use of **inductive** and **deductive** reasoning.
- This makes it very useful for explaining and/or predicting phenomena.
- The basic assumption of the scientific method is that every effect has a cause.

## What is Research (Contd.)?

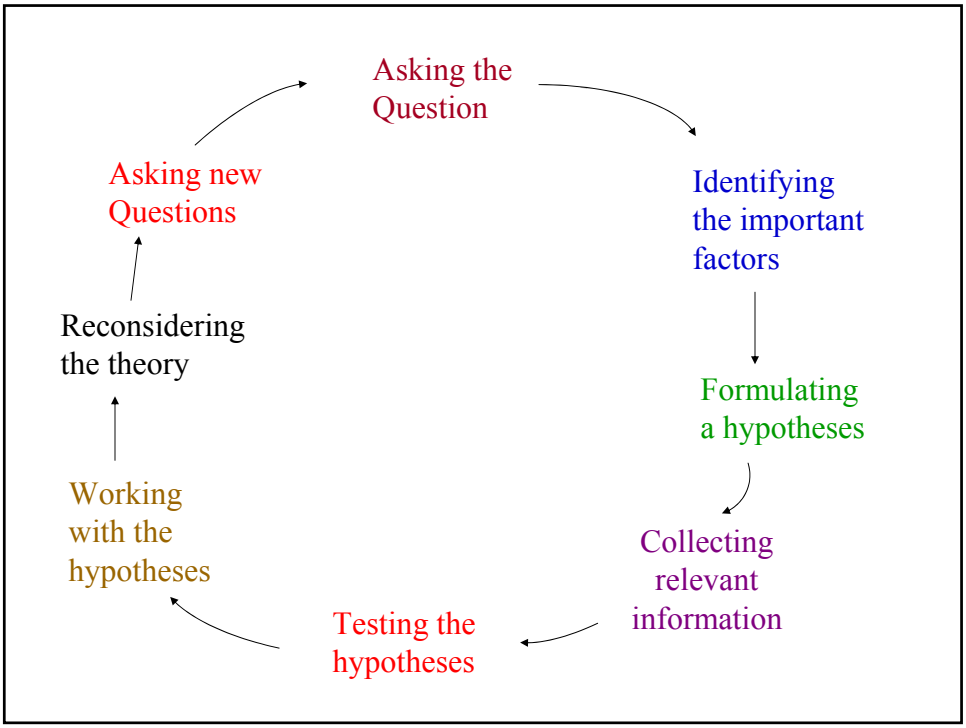
- It starts with the construction of hypotheses from casual observations and background knowledge (inductive reasoning) to reasoning out consequences or implications of hypotheses (deductive reasoning) followed by testing of the implications and confirmation or rejection of the hypotheses.
- Integrated use of inductive and deductive reasoning is, therefore, the essence of scientific method.




Scientific Method of Acquiring Knowledge of Problem Solving
*(By courtesy of Yadav & Menon)*

# Research

Where do I begin?




# [1] Overview of research and its methodologies

# Why do we need research?

- To get PhDs, Masters and Bachelors??
- To provide solutions to complex problems
- To investigate laws of nature
- To make new discoveries
- To develop new products
- To save costs
- To improve our life
- Human desires

## [1] Overview of research and its methodologies

1.1: Concepts of research
1.2: The need for research
1.3: Types of research
1.4: Steps in conducting research

## CLASSIFYING RESEARCH

- Reviewing related past research studies is an important step in the process of carrying out research as it helps in problem formulation, hypothesis construction and selection of appropriate research designs.
- It is beneficial if you can classify a research study under a specific category because each category or type of research uses a specific set of procedures.

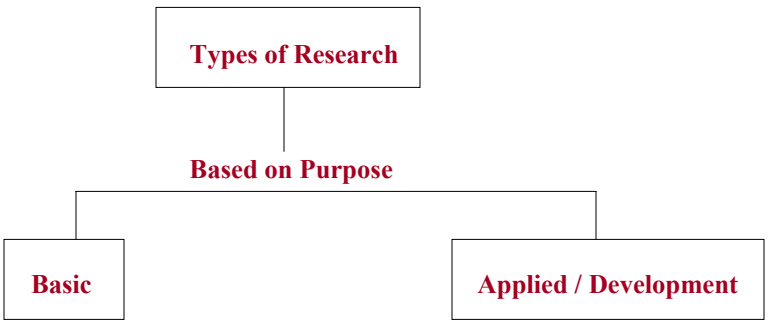
## Research can be classified into 2 types

Purpose

Method

- There are two ways of classifying research.
- One way is to classify research on the basis of its purpose i.e. the degree to which the research findings are applicable to an educational setting and the degree to which they are generalizable.
- The other is to classify research on the basis of the method employed in research.

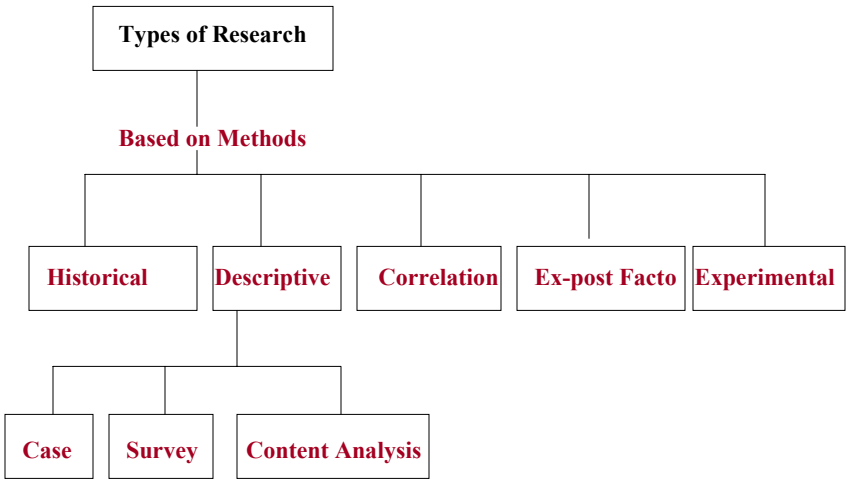
- Taking purpose as the basis of classification, research is considered to be two types-Basic and Applied (including Developmental research).




Classification of Research by Purpose

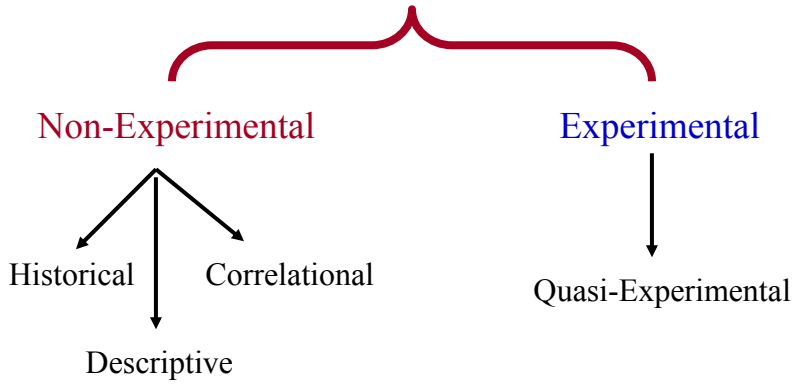
## CLASSIFYING RESEARCH BY METHODS

- The other basis for classifying research, is by the method it employs.
- Research method is characterized by the techniques employed in collecting and analyzing data.
- On the basis of method, research can be classified as historical, descriptive, correlational, ex-post facto and experimental.




Classification of Research by Method

# Different Types of Research
*(from Salkind)*




## 1. HISTORICAL RESEARCH

- The purpose of historical research is to arrive at conclusions concerning trends, causes or effects of past occurrences.
- This may help in explaining present events and anticipating future events.
- The data are not gathered by administering instruments to individuals ,but …

## *HISTORICAL RESEARCH*

- Rather, they are collected from original documents or by interviewing the eye-witnesses (primary source of information).
- In case primary sources are not available, data are collected from those other than eye-witnesses (secondary sources).
- The data thus collected are subjected to scientific analysis to assess its authenticity and accuracy.

## *An Example of Historical Research*
### *(from Salkind)*

- Nancy Burton and Lyle Jones (1982) examined trends in achievement levels of African American versus White children.
- They examined high school graduation rates between these 2 ethnic groups who were born before 1913, between 1913 and 1922, between 1923 and 1932, etc.
- They also examined a variety of historical indicators in more recent groups of African American and White children.
- One of their conclusions is that differences in achievements between these groups are decreasing.

## 2. DESCRIPTIVE RESEARCH

- Descriptive research studies deal with collecting data and testing hypotheses or answering questions concerning the current status of the subject of study.
- It deals with the question "WHAT IS" of a situation.
- It concerns with determining the current practices, status or features of situations.
- Another aspect of descriptive research is that data collection is either done through asking questions from individuals in the situation (through questionnaires or interviews) or by observation.

## *An example of Descriptive Research*

- Peter O. Peretti and Kris G. Majecen (1992) interviewed 58 elderly individuals, from 68 to 87 years of age, using a structured interview to investigate the variables that affect emotional abuse among the elderly.
- As a result of the interviews, they found 9 variables are common to elderly abuse, including lack of affection, threats of violence and confinement.
- *What kind of descriptive research is this?*

## 3. CORRELATIONAL STUDIES

- Descriptive and historical research provide a picture of events that are currently happening or have occurred in the past.
- Researchers often want to go beyond mere description and begin discussing the relationship that certain events might have to one another.
- The most likely type of research to answer the relationship among variables or events is called correlational research.

## *CORRELATIONAL STUDIES*

- A correlation study aims at determining the degree of relationship between two or more quantifiable variables.
- Secondly, the relationship thus determined could be used for making predictions.
- A high value of relationship, however, does not signify a cause and effect relationship which must be verified through and experimental study.

## *CORRELATIONAL STUDIES*

- Correlational research are studies that are often conducted to test the reliability and predictive validity of instruments used for division making concerning selection of individuals for the likely success in a course of study or a specific job.
- Some authors consider this research as a type of descriptive research, since it describes the current conditions in a situation.
- However, the difference lies in the nature of conditions studies.
- A correlational study describes in quantitative terms the degree to which the variables are related.

## *An Example of Correlational research*

- In a study (by Vaughn et.al., 1989) of the relationship between temperament and attachment behavior in infants, the correlation among different types of attachment behaviors, how securely attached the infants were to their mothers, and the infant's general temperament were examined.
- The researchers found that an infant's temperament does not predict how securely attached the child is to his or her mother.

## 4. EX-POST FACTO STUDIES

- There is some research where both the effect and the alleged cause have already occurred and are studied by the researcher in retrospect.
- Such research is referred to as EX-POST FACTO (after the fact).
- Kerlinger (1973) defines Ex-post Facto research as :

  "Systematic empirical inquiry in which the scientist does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable".
- Thus, in ex-post facto research or causal-comparative research the researcher has no control on the variables or he cannot manipulate the variables (independent variables) which cause a certain effect (dependent variables) being measured.

## *EX-POST FACTO STUDIES*

- Since this type of a study lacks manipulation of variables, the cause-effect relationship measured are only tentative.
- Some authors categorize Ex-post facto studies into the category of descriptive research.
- Though it too describes conditions that exist in a situation, it attempts to determine reasons or causes for the current status of the phenomena under study.
- The procedures involved in this study are quite different than those in descriptive research.

## 5. EXPERIMENTAL RESEARCH

- We already know that correlational research can help establish the presence of a relationship among variables but not give us any reason to believe that variables are causally related to one another.
- How does one find out if the characteristics or behaviors or events are related in such a way that the relationship is a causal one?
- Two types of research can answer this: (1) quasi-experimental research and (2) experimental research.

## *EXPERIMENTAL RESEARCH*

- Experimental research is where participants are assigned to groups based on some selected criterion often called treatment variable.
- Quasi-experimental research is where participants are preassigned to groups based on some characteristic or quality such as differences in sex, race, age, neighborhood, etc.
- These group assignments have already taken place before the experiment begins, and the researcher has no control as to what the people will belong to each group.

## *EXPERIMENTAL RESEARCH*

- The primary characteristic of experimental research is manipulation of at least one variables and control over the other relevant variables so as to measure its effect on one or more dependent variables.
- The variables (s) which is manipulated is also called an independent variables, a treatment, an experimental variables or the cause.
- Some of the examples of an independent variables could be: temperature, pressure, chemical concentration, type of material and conductivity.

## *An Example of Experimental Research*

- Experimental research will always have two or more groups for comparison on the dependent variables.
- It is the only type of research which can establish truly the cause and effect relations.
- Consider an Example
  - A researcher in technician education is interested in studying the effects of two methods of instruction-structured lecture method and programmed instruction on the achievement of students in a course of one semester in Applied Mechanics.
  - Sixty students in the class are divided randomly into two groups of thirty each.

- The groups receive the specified treatment for an equal amount of time during the semester.
- The participants are measured for their performance on the achievement test before and after the programme so as to measure the gain.
- In this experiment, the experimental or independent variables is the method of instruction and the dependent variable, is the achievement of students.
- The difference in the gain on achievement between the two groups will show the effect of the methods of instruction.

## Applied Vs. Basic Research

- The most basic distinction between the two research is that basic research is research that has no immediate application, whereas applied research is research that does.
- However, such distinctions are somewhat ambiguous as almost all basic research eventually results in some worthwhile application in the long range.

# [1] Overview of research and its methodologies

1.1: Concepts of research
1.2: The need for research
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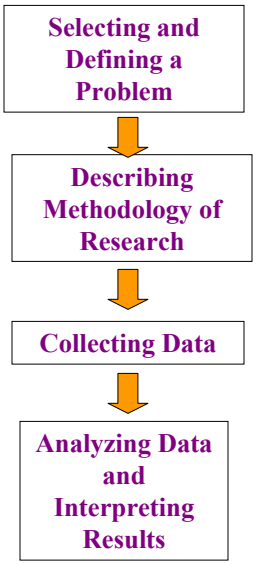
## Steps in Conducting Research

Irrespective of the category of a research study, the steps followed in conducting it are the same. These steps are :



## *Steps in Conducting Research*

1. Selecting and Defining a Problem

   This marks the beginning of a research study and is the most difficult and important step. This involves :

(1). identifying and stating the problem in specific terms;

(2). identifying the variables in the problem situation and defining them adequately;

(3). generating tentative guesses (hypotheses) about the relation of the variables or in other words the solution of the problem, or writing explicitly the questions (research questions) for which answers are sought; and

(4). evaluating the problem for its research ability.

## *Selecting and Defining a Problem*

- All this is not done in a vacuum.
- To achieve this, you review the literature related to the problem to know what other researchers have done and discovered and to identify the possible methodology for conducting the research.

## *Steps In Conducting Research*

2. Describing Methodology of Research

You need to state the purpose of the study and to define the problem clearly. This guides you in deciding the methodology of research which involves :

a. identifying the method of research;

b. specifying the subjects of study (e.g. heat flow problem, etc.);

c. selecting an adequate representative sample of subjects;

d. selecting/constructing valid and reliable instruments for measuring the variables in the problem;

e. selecting a research design and describing the procedure to be employed for conducting the research study.

## *Steps In Conducting Research*

3. Collecting Data

- This step involves conducting the study as per the designed procedure (manipulating the experimental variables in the case of an experimental method), administering instruments for measuring variables and/or gathering information through observation.

- It also involves tabulating the data thus collected for the purpose of analysis.

## *Steps In Conducting Research*

4. Analysing and Interpreting Results

- The results of the study are generated at this stage.
- The data are summarized, in other words analysed to provide information for testing the hypotheses.
- Appropriate statistical methods of analysis are used to test the hypotheses.
- You can perform the analysis manually, by using a hand calculator or a computer as per the demands of the problem, and the available facilities.
- After completing the analysis results are tied together or summarized.

- The results are interpreted in the light of the hypotheses and/or the research problem.
- These are then discussed in relation to : the existing body of knowledge, consistencies and inconsistencies with the results of other research studies, and then the conclusions are drawn.
- This is followed by writing the research report.

# Summary of Module 1

In this module, we have studied the following:

- Overview and Concepts of research
- The need for research
- Types of research
- Steps in conducting research

A 2-Day Course at GMI

# Research Methodology 2

## Module 2:
## Literature Review and Selecting and Defining a Research Problem

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# Research Methodology

## [2] Literature Review

[2.1] What is Literature Review?

[2.2] The Purpose of Literature Review

[2.3] How to Carry out a Literature Review?

## 2.1 What is Literature Review?

- It is actually the reading of the works of others before commencing on our own research work.
- Literature review can pave the way for better research.
- It can help in identifying the relevance of the research.

## Steps in reviewing the literature

- Define your idea in as general terms as possible by using general sources.
- Search through the secondary sources.
- Search through the primary sources.
- Organize your notes.
- Write your proposal.

## Different types of information and what they do!

- General sources
- Provides an overview of a topic and provides leads to where more information can be found.
- Examples are daily newspapers, news weeklies, popular periodicals and magazines, (e.g. IEEE Spectrum), etc.

## *Different types of information and what they do!*

- Secondary sources
- Provides a level of information "once removed" from the original work.
- Examples are books on specific subjects and reviews of research.

- Primary sources
- The original reports of the original work or experience
- Examples are journals, abstracts, scholarly books, etc.

# Research Methodology

## [2] Literature Review

[2.1] What is Literature Review?

[2.2] The Purpose of Literature Review

[2.3] How to Carry out a Literature Review?

## What are the purpose of Literature Review?

- To limit the problem area.
- To define the problem.
- To avoid unnecessary repetition.
- To search for new approaches.
- To recommend suitable methods.
- To sample current opinions.

## 2.2 The Purpose of Literature Review

- **LIMIT THE PROBLEM AREA**

  The problem should be small enough and sufficiently specific for adequate treatment and competent analysis. Research articles often suggest recommendations for the course that further research should take.

- **DEFINE THE PROBLEM**

  'Definition' means that the researcher knows exactly what he is looking for, so that data when collected and analysed actually relates back to the problem.

## *The Purpose of Literature Review*

- **AVOID UNNECESSARY REPETITION**

  Do not assume that because most of the existing research adopts one method that it is the only method or the correct method available in the circumstance. Do not use the approach if you have reservations about its application to the problem.

- **SEARCH FOR NEW APPROACHES**

  Be alert to research approaches which may have been overlooked. Be prepared to adopt a different viewpoint, particularly in areas where research is sparse.

## *The Purpose of Literature Review*

- **RECOMMEND SUITABLE METHODS**

  Methodology should be appropriate to the research problem. Compile a checklist in which you reference ideas on research design, instrumentation, sampling and data collecting and analysis from various studies.

- **SAMPLE CURRENT OPINIONS**

  Newspapers, magazines and non-technical articles may contain unique ideas that have not yet been researched.

# Research Methodology

## [2] Literature Review

[2.1] What is Literature Review?

[2.2] The Purpose of Literature Review

[2.3] How to Carry out a Literature Review?

# 2.3 How to carry out effective literature review?

- **A Plan for Obtaining Literature**

The following plan, arranged in a logical order is intended to provide a systematic means of obtaining relevant literature, once the general area of the research question has been established.

## *How to carry out effective literature review?*

1. **KEY WORDS**
   - compile a list of key word and terms that relate specifically to the research problem.
   - ensure that the list is exhaustive by checking terms in a dictionary.
   - cross reference terms/descriptors by using another dictionary/encyclopedia (if possible).

2. **CONSULTATIONS**
   - consult the librarian for information about the collection and cataloguing procedures.
   - discuss the research problem with specialists and/or colleagues for help in finding sources of literature.

## How to carry out effective literature review?

3. **PRELIMINARY SOURCES**
   - using the key words check the preliminary sources for references :
     - catalogue
     - indexes
     - abstracts
     - bibliographies
     - annotated bibliographies

4. **SECONDARY SOURCES**
   - locate textbooks, articles and other secondary sources (also the Internet).
   - check secondary sources for relevance and background information.

## How to carry out effective literature review?

5. **PRIMARY SOURCES**
   - locate research reports written specifically about the research problem.
   - check other primary sources for information on research design and methodology.

6. **CONTACTS**
   - write to organisations and/or institutions that may have an interest in the research problem and be able to supply information or additional contacts.
   - from the survey of primary sources, contact any person who may have conducted research in the area, if it is felt that this may be useful.

## [3] Selecting and defining a research problem

3.1: Problem formulation – why the need for this?
3.2: What are the criteria for selecting a problem?
3.3: Identifying variables
3.4: Evaluating problems
3.5: Functions of a hypothesis

## SELECTING A PROBLEM

- The central element in any research is the problem.
- One the problem has been identified and adequately defined, the systematic and scientific process of making observations and collecting data can be more easily carried out.
- From an analysis of the data collected, some significant results would be expected in anticipation of finding a solution to the problem

- However, you could say that a large part of the solution to the problem lies in knowing precisely what the problem is in the first place.
- After all, how can you solve a problem it you don't know what the problem is ?
- The prior planning of a research study is an important phase.
- Not only does a problem have to be identified, but before the research can begin to take shape, the problem has to be analysed and its exact dimensions specified.
- This is not an easy task, especially for the inexperienced researcher.

- The first question you ask is :

HOW DO YOU SELECT A PROBLEM ?

- Ideas for research topics do not usually come spontaneously !
- They can, however, spring from puzzling experiences.
- Sensing that something is wrong or out of the ordinary, or feeling unsure about a particular situation are conditions that give rise to problems.

- In the course of carrying out his work, a practitioner is likely to perceive problems.
- Often these problems are associated with his own particular area of expertise since that is the area he knows so well.
- On the other hand he may be curious or concerned about a troubling situation.
- Sometimes in an educational institution, decisions have to be made, on the basis of incomplete evidence.
- Of course, mostly there is insufficient time available for research to be undertaken that would provide the necessary relevant information for the immediate need, but the results could assist in the future.

- Problem situations emanating from this source would be particularly suitable for action research and applied research.

Can you think of a situation arising from your own personal experience that warrants further investigation?

## CRITICAL STUDY OF THE LITERATURE

- In preparing for a non-empirical research, general reading in your subject area or in any related area knowledge gaps in the literature may be identified.
- Perhaps conflicting points of view have been presented and there is a need for more information to be provided to support one or the other.
- Maybe there are deficiencies in the explanations given, or some questions may be raised that need answering.

## INTERACTION WITH OTHERS

- Conferences, meetings, workshops and in-service courses are usually designed for specific purpose, but often, during the course of the discussions, references are made to broader issues.
- As well, informal discussions with colleagues and other interested members of the public can lead the keen researcher to problem areas that could provide the basis for research.
- By being always eager to learn more about the educational process, by adopting a critical outlook and by taking every opportunity to be part of a research environment, it is more likely that you will be able to select a problem for research.

[3] Selecting and defining a research problem

3.1: Problem formulation – why the need for this?

3.2: What are the criteria for selecting a problem?

3.3: Identifying variables

3.4: Evaluating problems

3.5: Functions of a hypothesis

## What Are The Criteria For Selecting a Research Problem ?

- Interest
- Size/Scope
- Economy/Cost
- Researcher's Capabilities and Limitations
- Uniqueness

# Criteria For Selecting a Research Problem

(1) Interest

- If you are going to commit yourself to a piece of educational research, then it is important that you are interested in the topic you are researching.
- By being interested, you are more likely to read widely on the topic and have a more thorough knowledge of the situation.
- Background reading is an essential equipment for any person wanting to undertake a piece of research.
- Although this is a necessary requirement, it is not a sufficient criterion for selecting research problem.
- In fact, over-specialization can lead the researcher into investigating trivial problems that are of interest only to himself.
- On the other hand, the issue does not have to be of concern to everyone, but the results should be communicable and of interest to someone.

# Criteria For Selecting a Research Problem

(2) Size

- Here is where you need to exercise some professional wisdom.
- At the outset, problems are usually macro in size.
- This means that they are often too large for satisfactory results to be obtained.
- For example, a researcher wanting to investigate the quality of water in a certain area would be faced of determining the sample of water which is representative.
- However, further analysis, reduces the problem into a smaller and manageable research.

# Criteria For Selecting a Research Problem

(3) Economy

- Research are often confronted with practical constraints, not the least of which are time and money.
- What could have possibly been a worthwhile piece of research has often not been successfully completed because of the enormous personal sacrifice required on the part of the researcher in terms of the amount of time that can be devoted to the project and the amount of money required to carry it out.
- Even at the initial planning stages, it is wise to think about the possibility of receiving some support, both financial and non-financial, either from within your institution or from outside sources.
- Again, this may not be realised by direct monetary grants but could simply be in access to equipment-printing, stationery supplies, typing, etc.

# Criteria For Selecting a Research Problem

(4) Researcher's Capabilities and Limitations

- A researcher must recognize his own capabilities and limitations.
- If inexperienced in educational research, then it is highly likely that you will need some guidance.
- By organising for an advisor or for others interested in research or on your area of study to monitor your progress, especially in the planning stages, then it is quite likely that some of the ensuing difficulties will be overcome.
- It will be an advantage if you have people willing to support you throughout the research-to suggest alternative approaches, assist in clarification of issues, etc.

# Criteria For Selecting a Research Problem

(5) Uniqueness

- A researcher would not want to spend a lot of time and energy researching a problem if the answer to the problem already existed.
- That is, you would not want to duplicate a study.
- However, you may want to pursue a study similar to one already in existence but change the methods used, or modify the design, or use a different sample, or choose to perform different statistical analyses.
- You would then be replicating an existing study, and the research would then be considered unique in that it is not exactly like any other piece of research.

# Criteria For Selecting a Research Problem

- A researcher has to think about a number of issues when planning a research project.
- These *a priori* considerations are important for the future success of the project.
- Whether anticipating using the results for a specific practical purpose or not, there are a number of questions that need answering once a problem situation has been selected, before progressing any further.

# IDENTIFYING THE VARIABLES

- If your problem is too large (or global) you may have to eliminate some of the variables, or limit the size of the geographical area, or even the number of people involved. (At the same time it may be necessary to keep the purpose of the research in mind in case some basic necessary elements are eliminated.)

What is meant by a variable?

- A variable is a word used to describe a particular characteristic which all members of a set have, e.g. hair colour, age, intelligence, etc.
- These are human characteristics possessed by all.
- Of course, members of a set are expected to vary (hence the name variable) on the possession of the particular characteristic :

| | | |
|---|---|---|
| hair colour | - | blonde, dark, brown |
| age | - | old, young, infant |
| intelligence | - | high, low |

AS WELL THERE ARE DIFFERENT TYPES OF VARIABLES

Look at these examples.

HEIGHT - a continuous variable

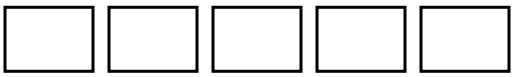
It allows continuous measures or graduated measures from short to tall.

SEX - a two-category variables

It permits only two characteristics : male or female. This is also called a (di meaning ‘two’ in Greek) variable.

RELIGION - a multiple-category variable

Thus allows for classification into several different categories- Hindu, Christian, Muslim, Buddhist, etc.



- The last two types of variables (dichotomous variables and multiple-category variables) are called discrete variables.
- Discrete variables enable you to distinguish between categories but it is not possible to distinguish between degrees of difference, nor can they be placed in any order.
- In most research, it is often necessary to limit the size of the problem in terms of the number of variables involved.
- When selecting a problem for study you need to look specifically at the relationship between variables.

# EVALUATING THE PROBLEM

- Having developed a well-constructed research question, it is important to consider :

  a. whether you think the research problem is FEASIBLE, and

  b. whether you feel the research problem is WORTHWHILE.

- Is the Problem Feasible ?
- The primary evaluative source is yourself.
- You should ask yourself a number of questions relating to the feasibility of the study – that is, whether it is possible for the problem to be solved.
- Some of the questions you have asked previously when considering criteria for selecting a problem situation or similar questions can be applied to the specific problem.

- You are seeking an answer to the question-,

Is the Problem Researchable ?

1. Has the problem been specified ?
2. Is the problem amenable to research ?
3. Is the problem too large ?
4. How available are the data ?
5. Am 1 capable of solving the problem ?

# CONSULTATION WITH OTHERS

- Having considered these questions and others like them yourself, it is wise to consult others (who are either experienced researchers, interested colleagues or experts in the field) for their honest opinions.
- Their evaluations, which would be based on the same foundations as yours, might focus on points that you have overlooked.
- They might also make some valuable suggestions which, at this state in the research process, would be most beneficial.They might suggest alternative approaches or present a different viewpoint or simply help you clarify your thinking.
- It is important to consider as may alternative ways as possible of looking at the problem.

Is the Problem Worthwhile ?

- The relative worth of a research problem will vary from person to person.
- The decision they make could depend on the usefulness of the research findings, or on the interest it holds for the readings or even on its contribution to the existing body of knowledge.
- In order to judge whether you research problem is worthwhile, you should ask yourself the question.

Will the Results be Significant ?

- In answering this question you are concerned with what are called social factors (or social considerations).
- When looking at the problem feasibility issue, you were mostly focusing on personal factors (whether you could cope with the research, whether the problem was too large for you to handle, etc.)
- To evaluate the worthwhileness of your research problem, you would need to ask questions such as :
    1. Will the results advance knowledge ?
    2. Will the research have some value ?
    3. Will the results be of interest to others ?

# FUNCTIONS OF A HYPOTHESIS

- Once a problem situation has been located and a problem refined to a researchable form, the researcher's task is to find an answer to the problem.
- If the answer to the question cannot be found from within the body of knowledge already in existence, it is necessary for the researcher to develop a hypothesis.

What is meant by a Hypothesis ?

- A hypothesis is an educated guess.
- It is an attempt to explain the nature of the relationship between the variables identified in the problem.
- If you like, a hypothesis is an attempt to suggest a possible answer to the problem based on available facts or information that the researcher already knows.

- Hypothesis are constructed in everyday life, e.g. when items are lost, when an unusual happening occurs or when something does not act in the normal way.
- In trying to find an answer to a problem situation, people construct hypothesis that direct them to finding the solution to a question.

Where did I leave the scooter key ?
What is that rumbling noise ?
Why didn't the mail arrive ?

- Perhaps you are familiar with questions of this kind and maybe there are many more that you can add to the list that are more pertinent to your situation.
- In order to solve the problem, you attempt to link what is known and what is not known and suggest a possible reason or solution.
- In this way you are hypothesising.

# DEFINITION OF A HYPOTHESIS

- A hypothesis can be defined as the tentative proposition suggested as a solution to a problem or an explanation of some observed state of affairs.
- It is a statement of the problem solver's expectations about a relationship between variables within a problem.
- A hypothesis can be used to solve simple or complex problems and is said to be the most powerful tool that a researcher has at his disposal.
- It gives the research a direction that the problem definition fails to give in that it indicates exactly which variables to examine and what relationship to look for.
- A research problem problem cannot itself be tested-it must be tested through the hypothesis that it generates.

A 2-Day Course at GMI

# Research Methodology

## Module 3

## Conducting the research and Examples of research at the university

Prof. Marzuki B. Khalid
Director
Center for AI and Robotics
Universiti Teknologi Malaysia


## [4] Conducting the Research

4.1: Research Activities in the Engineering Discipline

4.2: Example of research activity in Engineering (Industry)

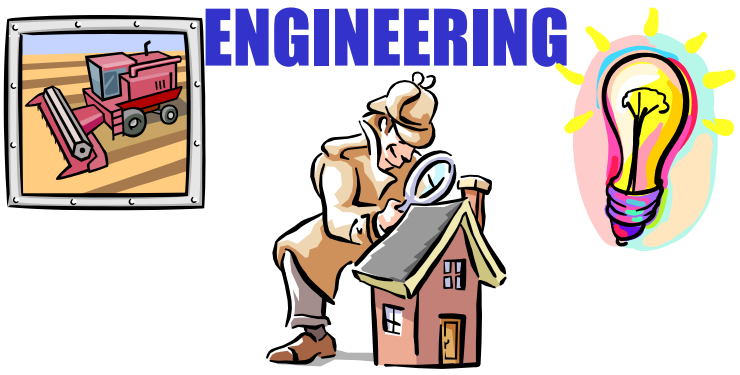
*Research Activities in the Engineering Discipline*

*Is there a difference in conducting research or in the research activities among the various fields of technologies/disciplines?*

Various fields of technologies/disciplines

- Engineering
- Business/Economics
- Law
- Medicine
- Biology
- Psychology/Behavioral Science
- Mathematics
- Pure Science (Chemistry, Physics, etc.)

# Our Focus:




# Engineering Disciplines:

- Electrical and Electronics
- Civil
- Chemical
- Mechanical

## Which types of research, does Engineering fall into?

- Historical
- Descriptive
- Correlation
- Ex-Post Facto
- Experimental

Non-Experimental

## Research in the Engineering disciplines belong to all the 5 types of research

- But which type/types would most Engineering research fall into?

# Need to look at some research topics in Engineering

- **"Learning and tuning of fuzzy logic controllers through reinforcements",** Berenji, H. R. and Khedkar, P. S., *IEEE Trans. on Neural Networks*, Vol. 3, No. 5, pp. 724-740, 1992.
- **"Optimal control -- 1950 to 1985",** Bryson, A. E., *IEEE Control Syst. Mag.*, Vol. 16, No. 3, pp. 26-33, 1996.
- **"A neural network controller for a temperature control system",** M. Khalid and S. Omatu, ***IEEE* Control Systems Magazine**, Vol. 12, No.3, pp. 58-64, June, 1992.

# Further examples of research topics in Engineering

- **"Self-tuning PID Control: A Multivariable Derivation and Application",** R. Yusof, S. Omatu, and M. Khalid, *Automatica*, Pergamon Press, Vol. 30, No. 12, pp.1975-1981, 1994.
- "**MIMO Furnace Control With Neural Network**", M. Khalid, R. Yusof, and S. Omatu, *IEEE Trans. on Control Systems Technology,* Vol. 1, No. 4, pp. 238-245, Dec, 1993.
- **"Effects of Different Genetic Operators on Minimum Time Motion Planning Of an Industrial Manipulator",** Ang Mei Choo and Dr. A.M.S. Zalzala, Elektrika, Vol. 4 No. 1, 2001.

## Activities in Engineering Research [1]

- Involve in the development of new algorithms/techniques/methodologies.
- Involve in the confirmation of newly proposed algorithms (applications to benchmark problems or laboratory equipment).
- Involve in the design of new products/circuits.
- Involve in comparing a number of different methodologies.
- Stability analysis on newly proposed algorithms.

## *Activities in Engineering Research [2]*

- Involve in the application of some proposed algorithms in novel applications.
- Involve in the study of certain aspects of dynamics (behavior) of plants/systems.
- Involve in surveys of some engineering aspects.
- Involve in market study of certain engineering products.
- Involve in the study on the effects of environmental factors on a particular product/design.

## *Activities in Engineering Research [3]*

- Involve in improving the design of existing products.
- Involve in extending the algorithms developed by others to a wider variety of applications/systems.
- Involve in the testing of new techniques extensively on benchmark problems in which earlier research has not done.

Thus, research in engineering disciplines would largely fall into the following categories:

- Descriptive research (Largely)
- Correlational research (Largely)
- Experimental research (Medium)
- Historical research (Very little)

## Review on Steps in Conducting Research


Are there differences between Research Activities in the Engineering Discipline and Others?

- Let's review some non-engineering research!

## *An Example of Historical Research*

- Nancy Burton and Lyle Jones (1982) examined trends in achievement levels of African American versus White children.
- They examined high school graduation rates between these 2 ethnic groups who were born before 1913, between 1913 and 1922, between 1923 and 1932, etc.
- They also examined a variety of historical indicators in more recent groups of African American and White children.
- One of their conclusions is that differences in achievements between these groups are decreasing.

## *An example of Descriptive Research*

- Peter O. Peretti and Kris G. Majecen (1992) interviewed 58 elderly individuals, from 68 to 87 years of age, using a structured interview to investigate the variables that affect emotional abuse among the elderly.
- As a result of the interviews, they found 9 variables are common to elderly abuse, including lack of affection, threats of violence and confinement.

## *An Example of Correlational research*

- In a study (by Vaughn et.al., 1989) of the relationship between temperament and attachment behavior in infants, the correlation among different types of attachment behaviors, how securely attached the infants were to their mothers, and the infant's general temperament were examined.

- The researchers found that an infant's temperament does not predict how securely attached the child is to his or her mother.

## *An Example of Experimental Research*

– A researcher in technical education is interested in studying the effects of two methods of instruction-structured lecture method and programmed instruction on the achievement of students in a course of one semester in Applied Mechanics.

– Sixty students in the class are divided randomly into two groups of thirty each.

- The groups receive the specified treatment for an equal amount of time during the semester.
- The participants are measured for their performance on the achievement test before and after the programme so as to measure the gain.
- In this experiment, the experimental or independent variables is the method of instruction and the dependent variable, is the achievement of students.
- The difference in the gain on achievement between the two groups will show the effect of the methods of instruction.

## Differences between Research Activities in the Engineering Discipline and Others? [1]

- Engineering research are more formulative in nature.
- A lot is based on mathematics.
- Experiments are conducted on machines, rather than humans or animals.
- Data to be collected differ significantly.
- Hypotheses arrived at are largely based on mathematical proofs, rather than just an educated guess.

## *Differences between Research Activities in the Engineering Discipline and Others? [2]*

- Experiments can be done within a shorter period of time.
- Outputs in engineering research are more tangible such as a software, a new machine or component, or even mathematical equations, etc.
- Engineering research do not differ much in different regions of the world.

## [4] Conducting the Research

4.1: Research Activities in the Engineering Discipline

4.2: Example of research activity in Engineering (Hitachi, Japan)

1

# SCMJ
# and
# HIGH END COMPUTER


Hitachi Ltd.
Hitachi Engineering Co., Ltd.

# CONCLUSION

2

## SCMJ/NEUPLANET

EVOLUTIONARY THINKING
and ARTIFICIAL-LIFE METHOD

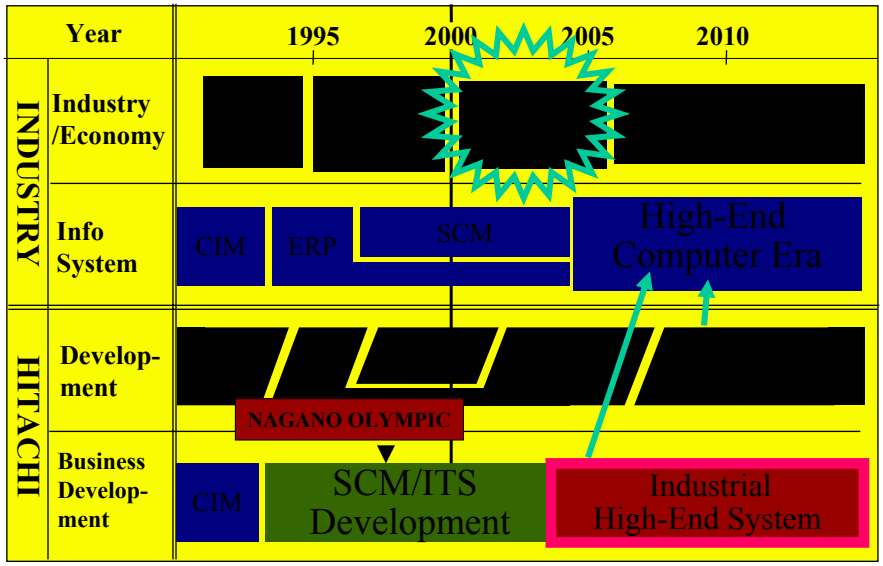
## HIGH END COMPUTER

# 1

# Background of Development



History of Industry and Information Field in Japan



## CURRENT SITUATION in JAPAN

5

in A CRITICAL SITUATION!

↓

DEREGULATION was Performed

↓

COST of PRODUCTS is very HIGH!

↓

REASON:COMPLEX LOGISTICS!!!

↓

ACTION REQUIRED:
PROMOTE THE TOTAL OPTIMIZATION

→ SCM

## Optimum # Of DEPOTS

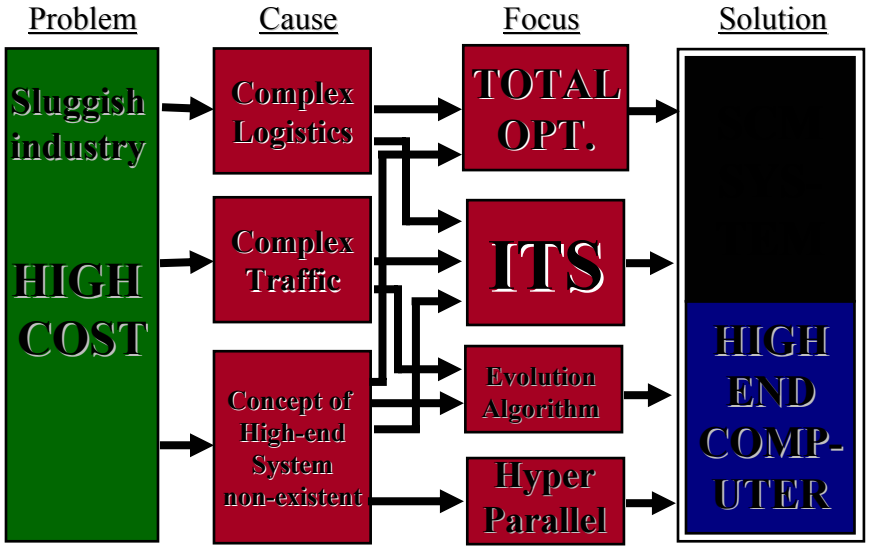
6

| | year1998 | year2005 |
|---|---|---|
| (1)Oil Prod. | 420 | 47 |
| (2)Daily Prod. | 2670 | 189 |
| (3)Milk Prod. | 817 | 20 |

**CONCLUSION**

**3/4 should be eliminated**

## PROBLEMS and SOLUTIONS






# 2

# SCM
# Supply Chain Management

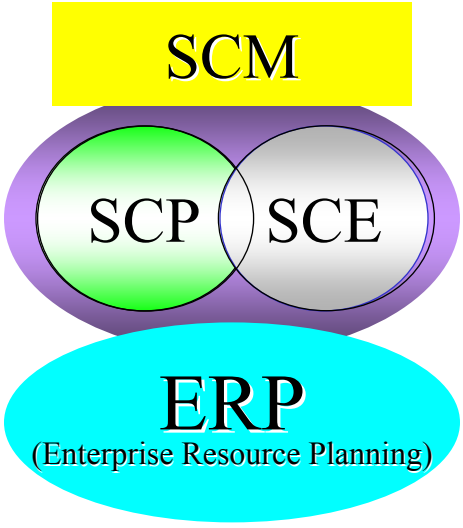
# What is SCM?



**It is to MANAGE the SUPPLY CHAIN of products efficiently and scientifically.**

# 2 kinds of SCM Systems






**SCE**
(Supply Chain Execution)

.Mechanism for executing SCM - Software/System
.Necessity of high process ability - to execute order entry, forecast, planning and control in real time.

**SCP**
(Supply Chain Planning)

.To support decision making and planning process - Software/System
.Necessary to process massive data efficiently

SCE includes SCP .

11

Difference between
SCP(plan) and SCE(Execution)

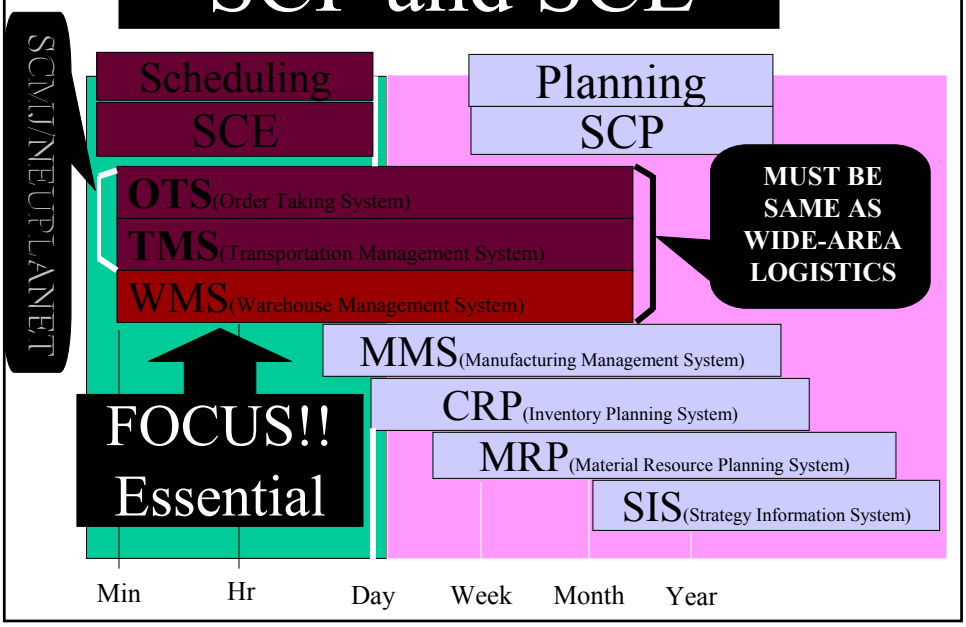
PLAN=Long Term
For Executive and Manager

Schedule=Time Table
For Field

Many people are mixed up!

12

# SCP and SCE



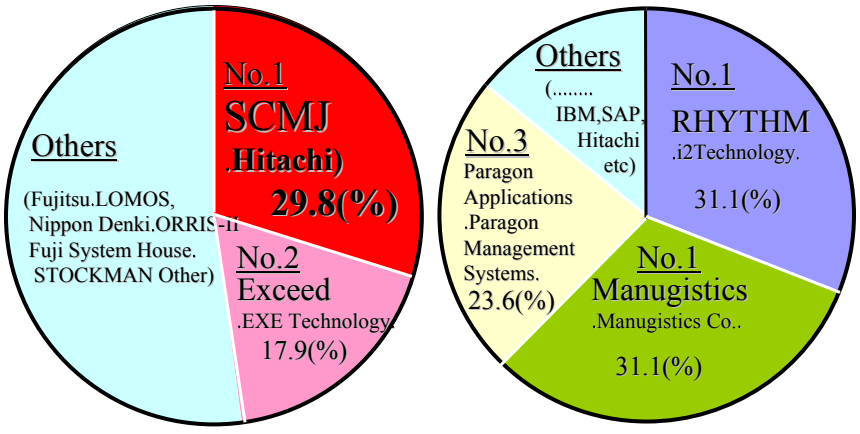
# Large Scale SCM Execution System

must be equivalent to

# Wide Area Logistics System (REAL TIME!)



## Actual Result for Share in1998 in Japan




SCE Share SCP Share

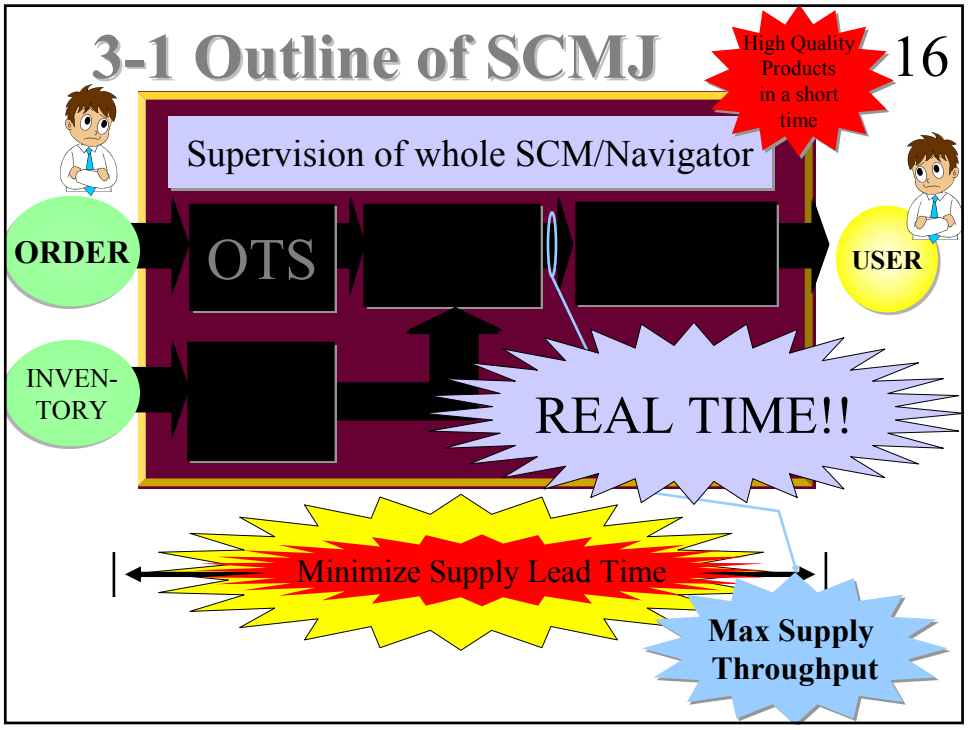
*SCE includes SCP functions.

# 3

# SCMJ NEUPLANET



## 3-1 Outline of SCMJ

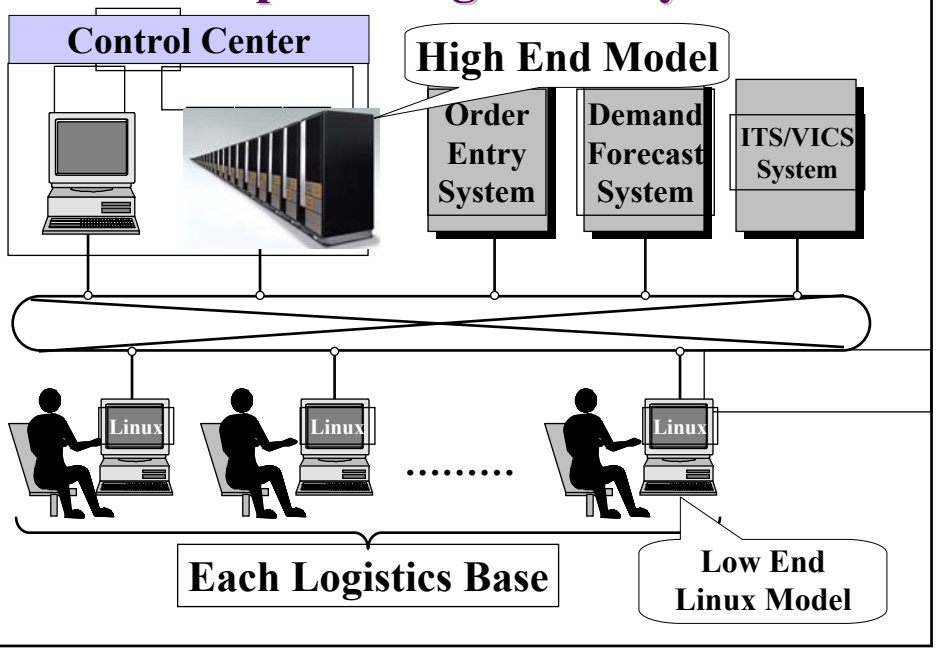


# 3-2 System Scalability

| No | CLASS | Hard Ware | OS | Price | User Class |
|---|---|---|---|---|---|
| 1 | Low End | PC | Linux | Very Low | Branch Base |
| 2 | Stan-dard | WS | UNIX | Mid. | Single Enter-prise |
| 3 | High End | HEC | UNIX +a | Mid. High | Nation Wide World Wide |



## Example of High End System



# 3-3 Functions



S C M J

High Performance
Parallel Computer

AWARD
SOFTWARE PRODUCTS
OF
THE YEAR '99
in Japan

(1) ITS

- GIS Nationwide Process
- Transportation Link Creation
- Logistics Info Process
- ITS/VICS Linkage
- Optimize Route Search

(2) SCM

- High-Speed Planning
- Cost Minimization
- GIS Interface
- GUI Screen Process
- Report Generation

(3) HEC



# 3.3-(1) ITS Demonstration

Using actual H9000 System

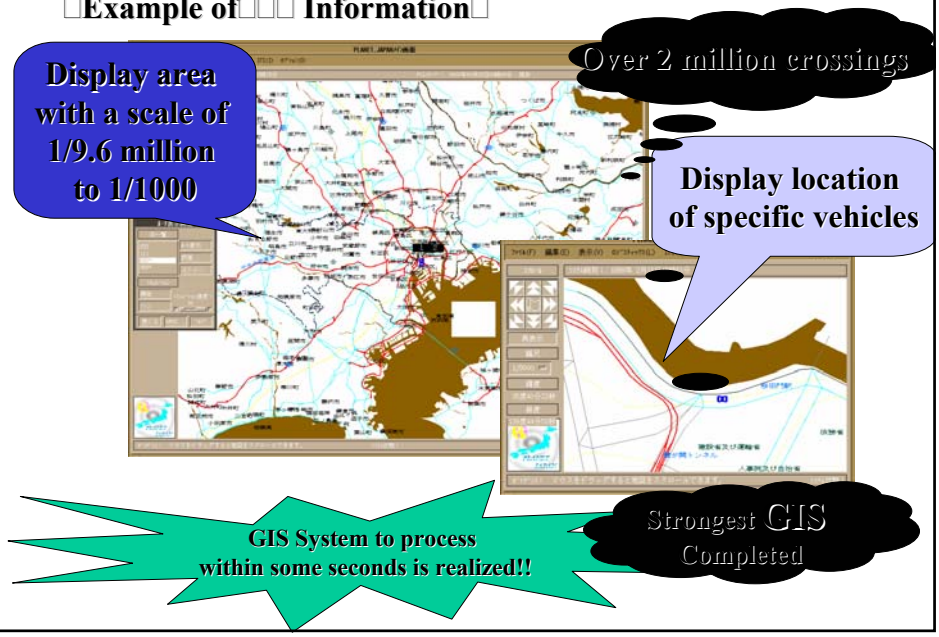
1 High-Speed Digital Road Map Control(Display, Scroll etc)

2 Advanced traffic control ITS-MOCS/DRGS

## Nation-Wide-Area ITS Technology

21

□Example of□□□ Information□




## Demonstration - ITS

22

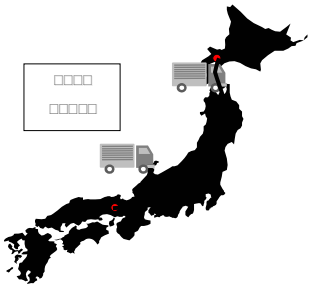
**ITS**

- **GIS** — **Geographic Information System** / **Digital Road Map**
- **VICS** — Vehicle Information and Communication System
- **MOCS** — Mobile Operation Control System
- **DRGS** — Dynamic Route Guidance System

## ITS MOCS & DRGS 23

**MOCS :** Users can get information of accurate locations and time of their own vehicles without using GPS. This means that users can save big money.

DRGS: Drivers can get optimum route information to their destinations easily. This means that users can save time and energy.



**Please confirm that MOCS and DRGS will be the most important systems in the 21st century.**

24

# ITS Demo. (2)

Using VIDEO MOVIE(5min)

Advanced ITS systems
at
NAGANO Olympic Games
in Feb. 1998

# 3.3-(2) SCM Functions



## MASTER INFORMATION

### Customer Information Master

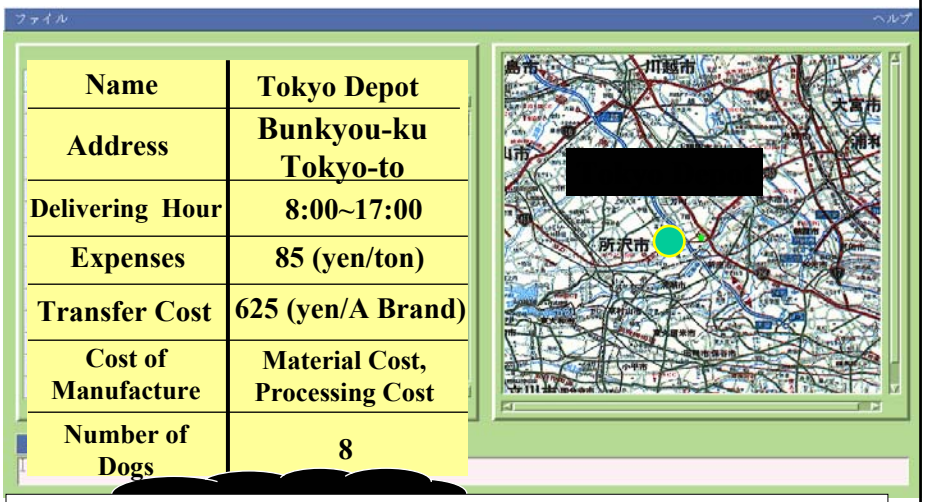
| | |
|---|---|
| Name | Shop A |
| Address | Minato-ku, Tokyo |
| Delivery Hour | 9:00~17:30 |
| Priority | Very Strict |
| Maximum Vehicle Size | 4 (ton) |
| Inventory level | Each kind of product |
| Customer Requirement | Automated Planning |


**Contains 200 or more detail Items**

# Logistics Center Master

27

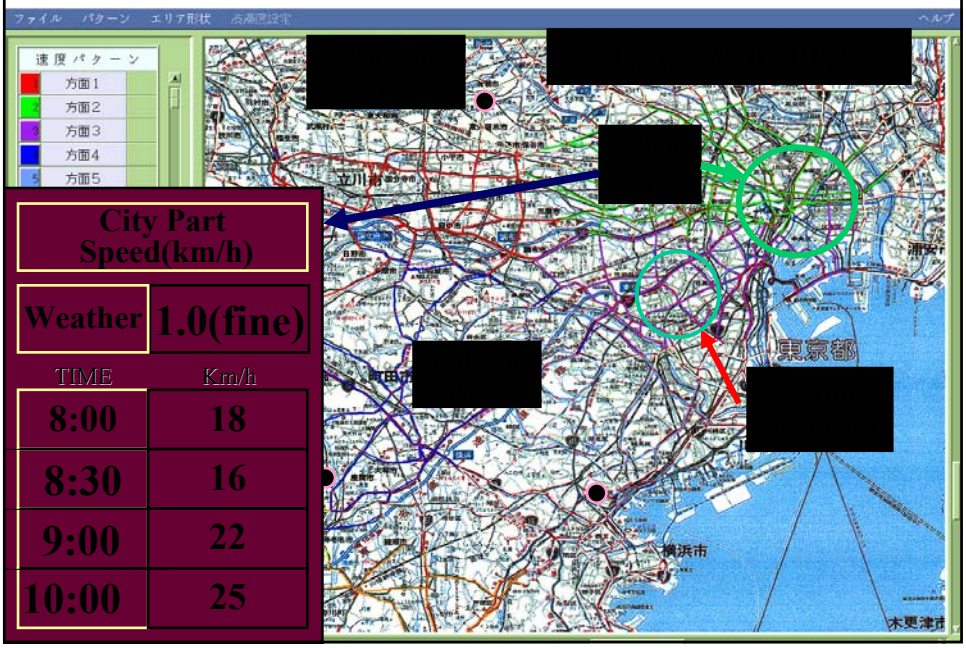
(Factories, Warehouses, Ports)




**Contains 200 or more detail Items**

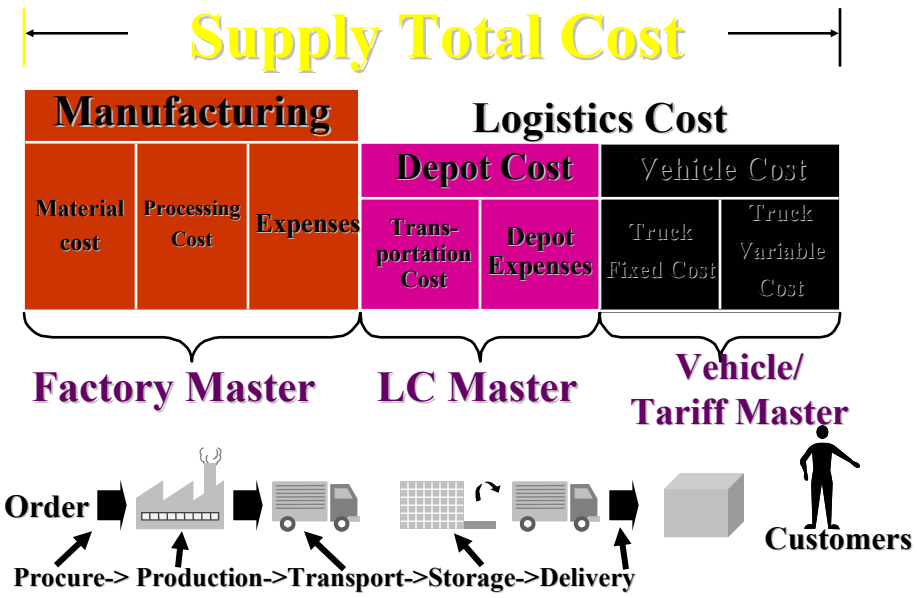
# Speed Master -Traffic Condition Reflection

28



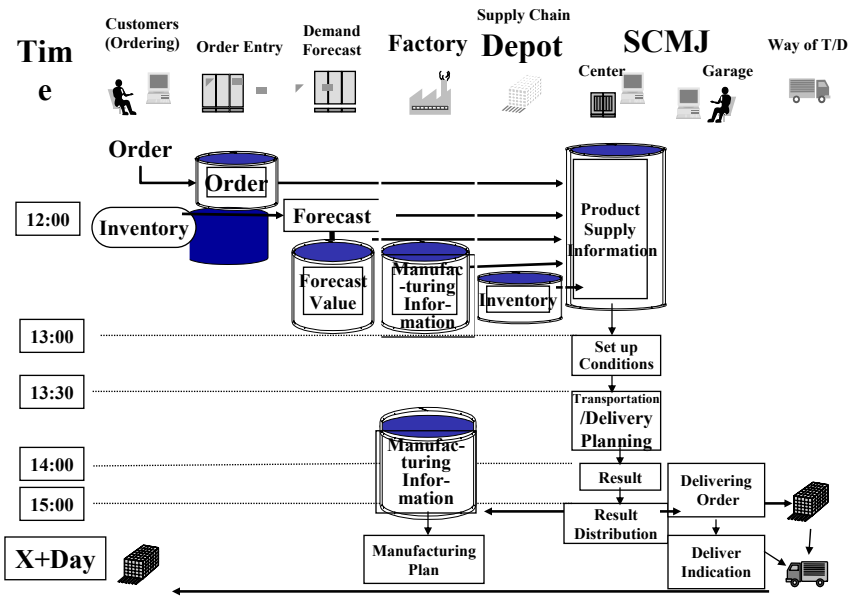
# Cost Definitions






# SCM Daily Operation (SCM Execution)





## Setting up Working Status for Depots 31

### <E.g.>New York Depot□December 31st 1998

### Set up LC and Working Status

| LC Name | New York Depot |
|---|---|
| Calendar | Effective on Dec. 31st |
| Deliver hour | 7:00-18:00 |
| Inventory Kind - A | 2500 |
| B | 800 |
| C | 4000 |
| D | 0 |
| E | 0 |


## Setting up Working Status for vehicles 32

### E.g. Allocation vehicles at Kawasaki Depot

Trans. Company Name　　CAN WORK　　CAN'T WORK

# Scheduling Control Screen



**No of CPU**

**128**

**Generation**

**800**

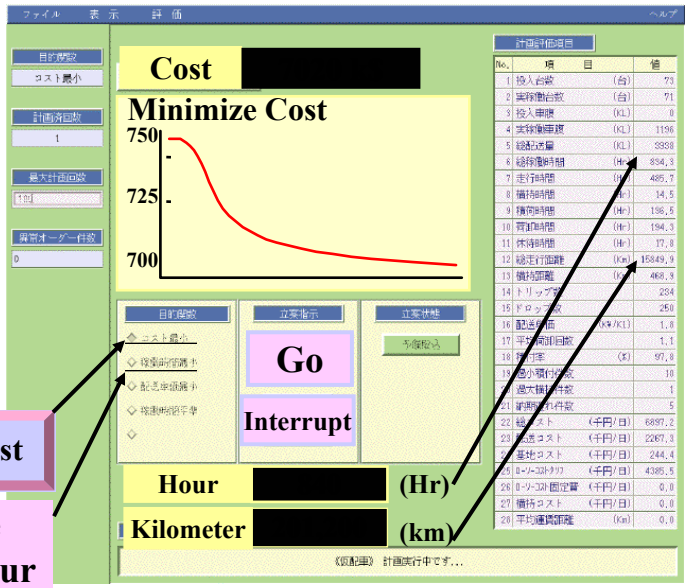
**Processing Time**

**8** Min.

**47** Sec.

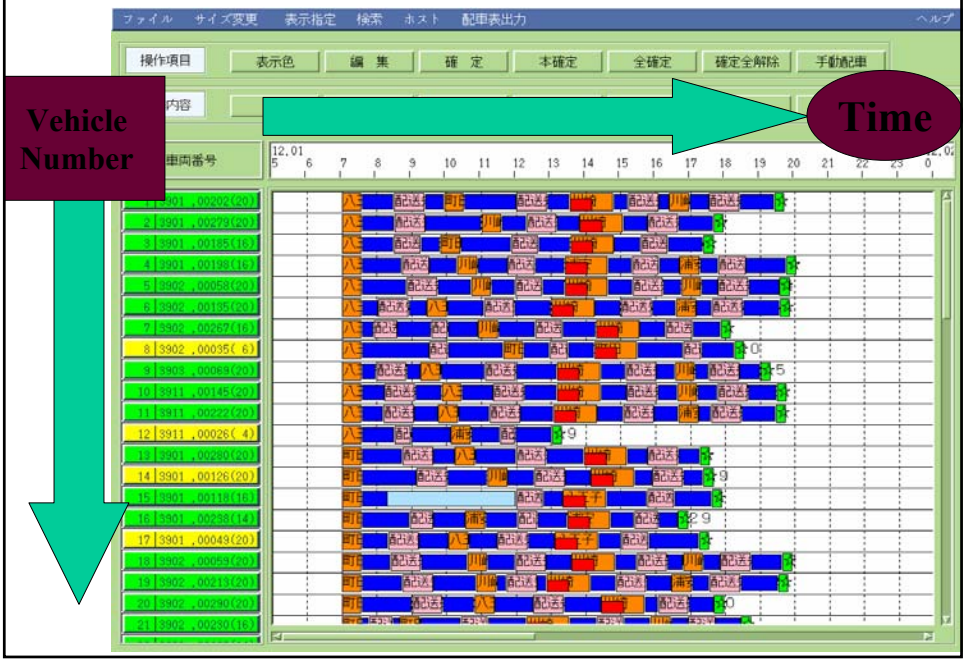
**Minimize Cost**

**Minimize moving Hour**



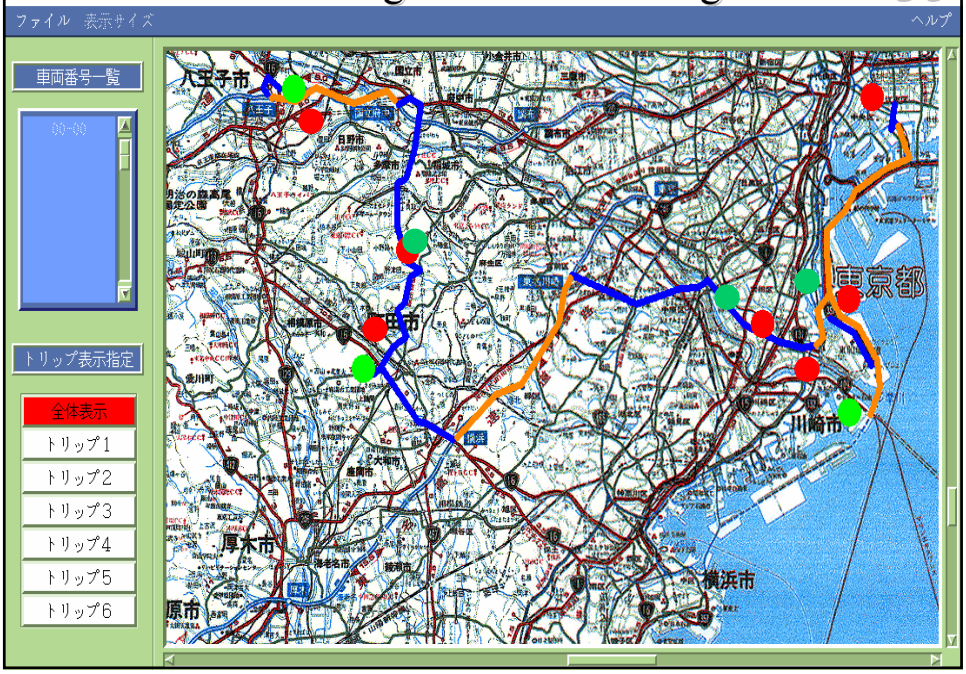

# Check the Planning Results / Gant-Chart





# Check the Planning Results / Running Route






# 3.4 Users



## □Total.120 (Systems)

**(1) Oil business.SS company,CS Company, J Company and others**

**(2) Food business.Morinaga Dairy Products, M Dairy Products and others**

**(3) Governmental and municipal offices.**
**Nagano Olympic Games,**
**Ministry of Posts & Telecommunications,**
**Ministry of International Trade and Industry,**
**and others**

**(4) Others : K Commodity Co., N Transport Co.**

## 3.5 ACTUAL EFFECTS

# 10 - 50 (%)

# Cost Reduction



## 3-6 Remarkable Points in the Market

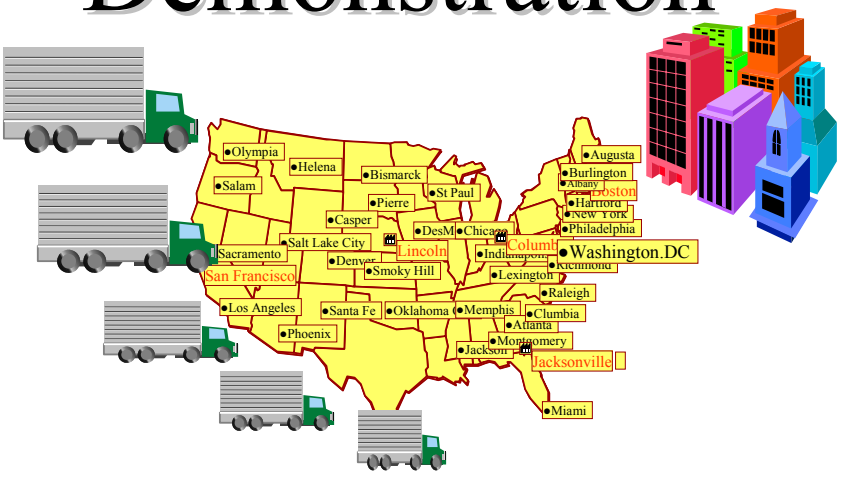
(1) Prize winning "Software Product of The Year '99"( MITI)


(2) Largest market share obtained in SCE sales (1997-1998, 29.8(%))


(3) "GIS Model Business" selected by MITI (Ministry of International Trade and Industry)


(4) 4 Business books are published Best seller! Published in Korea

# Going to Demonstration




[5] Examples of research at the university

- 5.1: Differences among Postgraduate and Undergraduate Research
- 5.2: Research at the postgraduate level (PhD and MSc)
- 5.2 Research at the undergraduate level (BSc)
- 5.3 Preparations for an undergraduate final year project

## Differences in Postgraduate and Undergraduate Research

Postgraduate Research

- Time (Longer)
- More algorithmic /mathematical
- Applications should be novel
- More detailed analysis

Undergraduate Research

- Time (Shorter)
- Emphasis is not on developing of new algorithms
- Applications not necessarily novel
- Analysis need not necessarily be substantial

## Research Program at the University *(Time frame)*

- PhD: 3-4 years:
- Masters by Research: 1.5-2 years
- Masters by Instruction (Course): 3-6 months
- Bachelors: 3-4 months

## Research Program at the University
*(Differences in levels)*

- PhD: More algorithmic, development of new techniques, extension of existing new techniques, and/or novel applications.
- Masters by Research: Mainly novel applications, applications of relatively new techniques or algorithms, comparisons of techniques.
- Masters by Instruction (Course): Case studies, mostly similar to Bachelor projects with more analysis.
- Bachelors: Application of existing techniques, case studies, software or circuit design to implement existing techniques.

## [5] Examples of research at the university

# New Developments in Neuro-Fuzzy Control Systems (at CAIRO, UTM)

**Main objectives of this research**

***To construct self-learning and adaptive neuro-fuzzy control systems based on hybrid AI techniques.***

# Proposed 3 Strategies:

- Self-Organizing Neuro-Fuzzy Control System by GA
- Adaptive Neuro-Fuzzy Control System using GRNN

  *(Proposed New Features in GRNN for Modelling of Dynamic Plants)*
- Combination of the above Two Approaches

Motivation

# Development in AI based control systems

- **Integration / fusion at algorithm level**
  - **Flexible and dynamic techniques**
  - **ES + FS = FE systems**
  - **FS + NN = NF systems**
  - **NN / FS + CT = Self-Organizing/Learning control systems**
    **(Adaptive Neuro-Fuzzy C.S.)**

Comparison of FLS, ANN, GA, conventional control theory and symbolic AI.
*(investigated by Fukuda and Shibata (1994))*

| | FLS | ANN | GA | Control Theory | Symbolic AI |
|---|---|---|---|---|---|
| Mathematical model | SG | B | B | G | SB |
| Learning ability | B | G | SG | B | B |
| Knowledge representation | G | B | SB | SB | G |
| Expert Knowledge | G | B | B | SB | G |
| Nonlinearity | G | G | G | B | SB |
| Optimisation ability | B | SG | G | SB | B |
| Fault tolerance | G | G | G | B | B |
| Uncertainty tolerance | G | G | G | B | B |
| Real-time operation | G | SG | SB | G | B |

G: good SG: slightly good SB: slightly bad B: bad

The major success of Fuzzy Logic in the mid-eighties is mainly due to its introduction into Consumer Products

- Some Examples are:
  - Washing Machines
  - Camcorder
  - Refrigerators
  - Televisions
  - Rice Cookers
  - Air Conditioners
  - Brake control of vehicles
  - Heaters

In 1990 Fuzzy Logic Consumer Products entered Japanese Consumer Market in a Big Way:

# Problems with conventional fuzzy systems

- **Difficulty in choosing the correct fuzzy rules, especially for complex systems**
- **Does not work well in unexpected circumstances**
- **No systematic approach of tuning the membership functions, sometimes laborious or time-consuming**
- **No self-learning capability**
- **Non-adaptive in nature**

# Development in AI based control systems

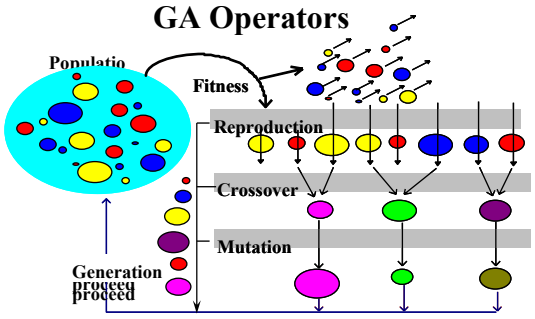
- **Hybridization at knowledge acquisition**
  - From Expert knowledge or through Learning
    - 2 common numerical learning approaches
      - **neural learning & evolutionary approach (GA)**
- **Hybridization at functional level**
  - Functional suitability
    - **NN -->modelling & prediction**
    - **Neuro-fuzzy system--> control**
    - **FES --> supervision**

# Development in AI based control systems

- **Combination at design & implementation level**
  - **To take full advantage and benefits of their capabilities**
  - **e.g., fuzzy rules initially generated through neural clustering algorithm, followed by re-selection using GA**
  - **e.g., GA learning (offline) followed by neural tuning (online)**

*****Complementary rather than competitive*****

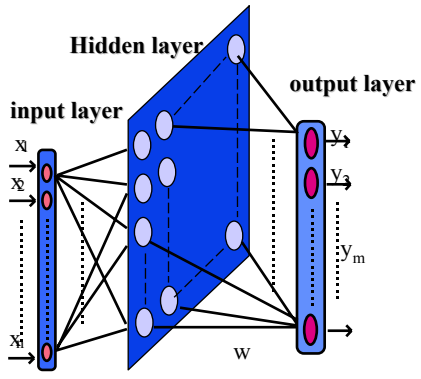
Self-Organizing Neuro-Fuzzy
Control System by Genetic Algorithms




## The radial basis neurofuzzy controller (NFC)

- **Based on RBF NN**
- **A simplified fuzzy control algorithm (Linkens and Nie)**
- **Singleton output membership**
- **Matching degree and weights averaging**
- **NN** (learning cap.) + **FS** (structured knowledge)

## Structure of the neuro-fuzzy controller (NFC)




IF <antecedents> THEN <consequents>

- RBF NN
- Gaussian m.f. (2-parameters)
- Each radial unit =one control rule
- Each connected weight = one control action
- Matching degree calculated at the radial units

## Matching degree

$$h_i = \exp\left(-\left\|\frac{C^i_{x,n} - \underline{x}}{d^i_{x,n}}\right\|^2\right)$$

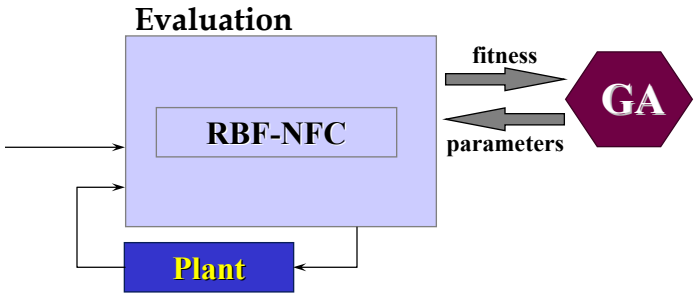
h - inferred result of the antecedent

## Weights averaging

To obtain overall output ; similar to COG method

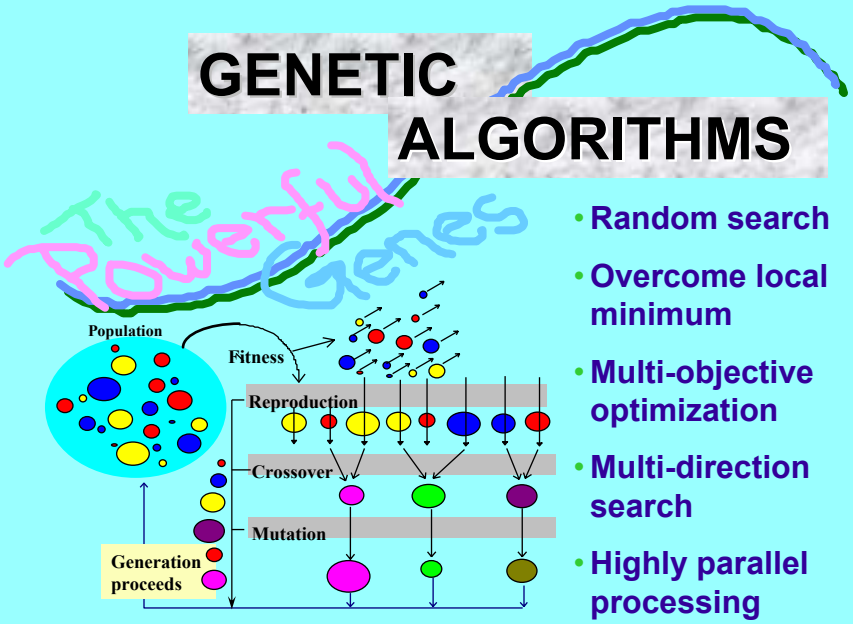
$$y_m = \sum_{i=1}^{p}\left(h_i \cdot w_{im}\right) \Big/ \sum_{i=1}^{p}\left(h_i\right)$$

# Self-Organizing NFC by GA




simultaneously !!

# GENETIC ALGORITHMS




- Random search
- Overcome local minimum
- Multi-objective optimization
- Multi-direction search
- Highly parallel processing

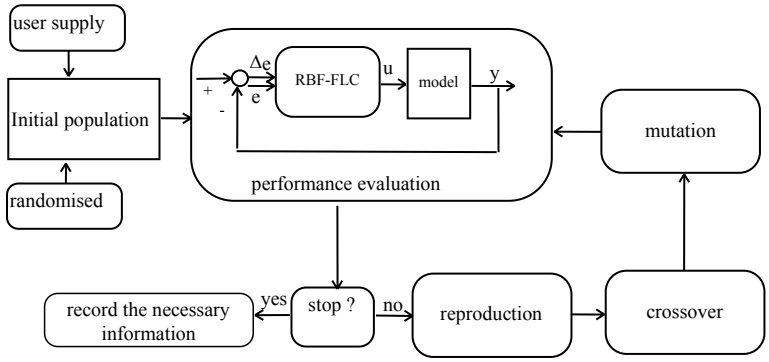
## Why GA ?

- Random / probabilistic search
- Coded parameters - multiple model problems
- Population approach- many directions simultaneously, avoid local points
- Fitness method- no assumption on set-point; ill defined & non-deterministic work space
- Performance analysis & iterative evaluation- insensitive to noise
- Simple - Reproduction, crossover & mutation

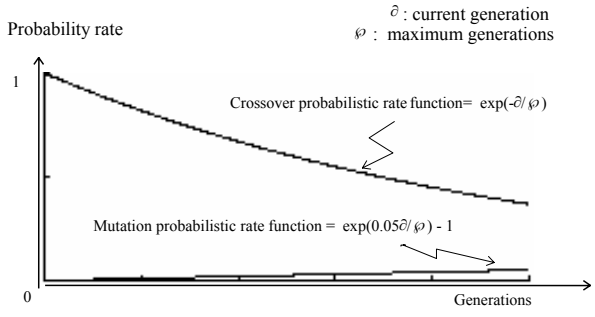
## GA configuration

- **200 chromosomes, initially randomised, linear mapping coding**
- **Gray-scale**
- **Roulette wheel selection scheme**
- **Elastic strategy, generation gap of 0.9**
- **Two-point crossover** (Px>>Pm)
- **Dynamic probabilistic rates** {pc=exp(-a.c/T); pm=exp(b.c/T)-1}
- **E-ΔE of the NFC: 5 m.f. for each input**
  **-- 45 parameters, 8 bits each, 360 bits length**

# A functional block diagram showing the GA optimisation process.




# We use a dynamic crossover and mutation probability rates in our applications.



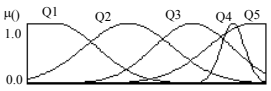
## Experiments on the Self-organising NFC by GA

- An open-loop non-minimum phase plant with an unstable pole
- A nonlinear plant
- An automatic car parking mechanism
- A coupled-tank system
- ** diff. perf. indexes --> diff. obj.

## Application to a non-minimum phase plant having an open loop unstable pole

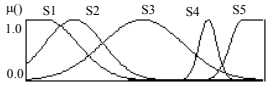
$$G(s) = \frac{(-0.67s^2 + 5.52s - 9.437)10}{(s - 0.559)(s^2 + 27.388s + 12.6244)}$$

# NFC fuzzy input membership functions and weights tuned by GA for the unstable plant




Fuzzy membership functions of error (e)

| label | Q1 | Q2 | Q3 | Q4 | Q5 |
|---|---|---|---|---|---|
| centre | -0.96 | -0.45 | 0.00 | 0.28 | 0.42 |
| width | 0.41 | 0.44 | 0.38 | 0.17 | 0.44 |

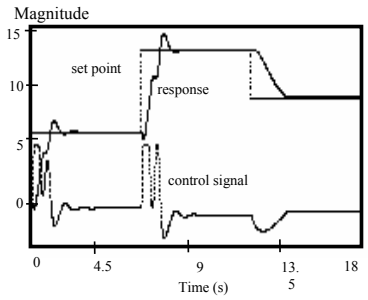



Fuzzy membership functions for change of error (Δe)

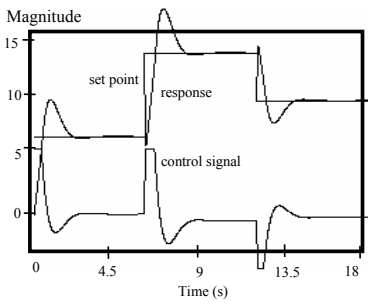
| label | S1 | S2 | S3 | S4 | S5 |
|---|---|---|---|---|---|
| centre | -0.064 | -0.041 | 0.000 | 0.044 | 0.062 |
| width | 0.029 | 0.026 | 0.036 | 0.008 | 0.011 |

| $\Delta e$ \ $e$ | Q1 | Q2 | Q3 | Q4 | Q5 |
|---|---|---|---|---|---|
| S1 | -0.019 | 0.660 | -0.043 | -0.036 | -0.379 |
| S2 | 0.812 | -0.687 | -0.415 | -0.344 | 0.345 |
| S3 | -0.015 | 0.042 | 0.000 | 0.382 | 0.269 |
| S4 | -0.360 | 0.121 | -0.342 | -0.912 | -0.650 |
| S5 | 0.437 | 0.261 | -0.256 | 0.255 | 0.173 |

# Comparison with a GA-tuned PID controller on an open loop non-minimum phase unstable plant




Proposed Method




GA-tuned PID Controller

## Application to a nonlinear plant

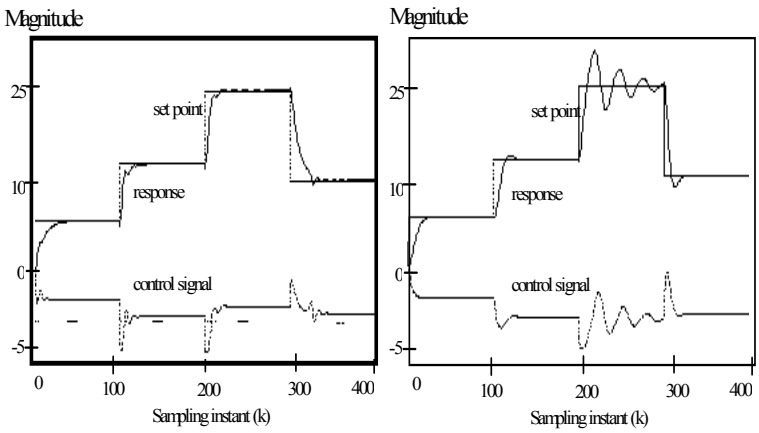
$$y(k)= 0.79y(k-1) + 0.012y(k-1)y(k-2) - 0.005y^2(k-2) + 0.15u(k) -0.8u(k-1)$$

$$F = \sum_{i=1}^{L}\left[ s_i \sum_{k=1}^{N_i}\left\{e^2(k).k^4\right\} \right]$$

Fitness function of GA

Examples of Application of the Self-Organizing NFC by G.A.

### Response of the nonlinear plant

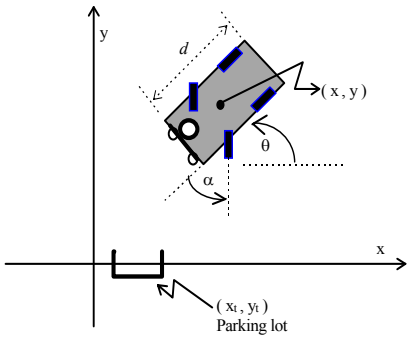


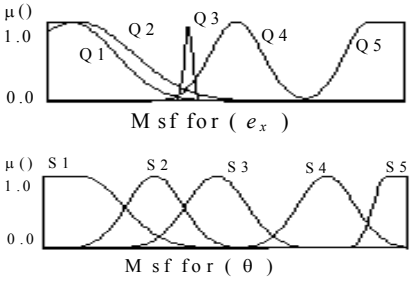

**Proposed Method**

**Manually tuned CFLC**

# Application to a car parking mechanism

*(Tanaka and Sano, 1995)*



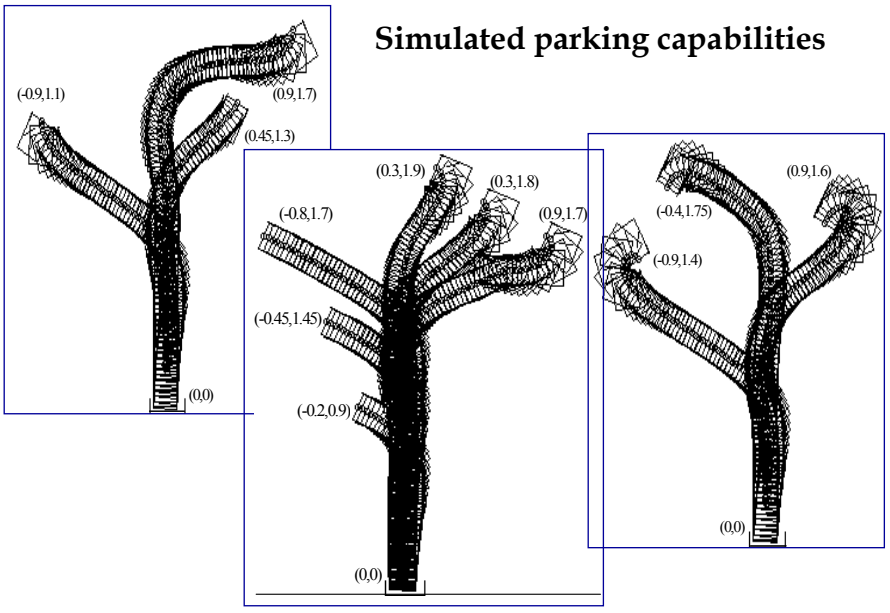




$$F = \sum_{i=1}^{L}\left[\sum_{k=1}^{N_i}\left(\left[e_x^2(k)+1\right].\left[e_\theta^2(k)+1\right].k\right)\right]$$

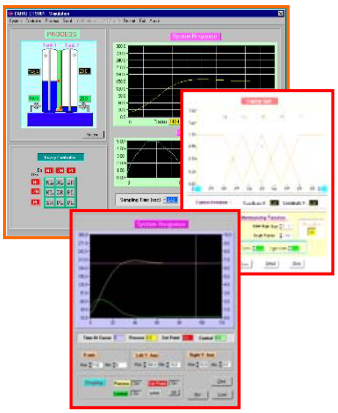
| $e_x$ / θ | Q1 | Q2 | Q3 | Q4 | Q5 |
|---|---|---|---|---|---|
| S1 | -1.15 | -1.15 | -1.18 | -1.07 | -1.10 |
| S2 | 0.08 | 0.81 | 0.86 | 0.75 | -1.03 |
| S3 | -0.41 | 0.48 | 0.94 | 1.10 | 1.08 |
| S4 | -1.16 | -0.69 | 0.00 | 1.11 | 1.09 |
| S5 | -1.17 | -1.16 | -0.27 | 0.03 | 0.36 |

Examples of Application of the neuro-fuzzy controller by G.A.

## Simulated parking capabilities



## Application to a Liquid-level Coupled-tank Computer-controlled System (CAIRO's)

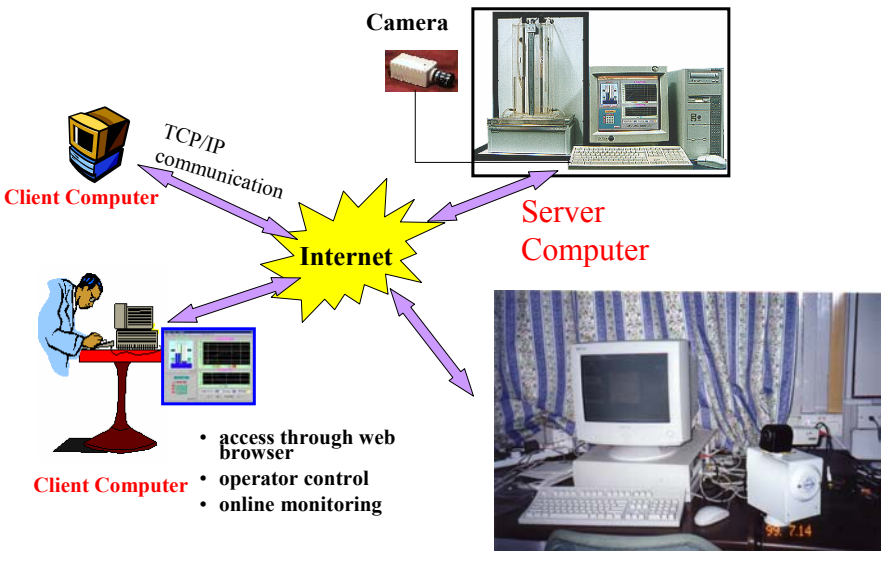


The Coupled-Tank Dynamics:

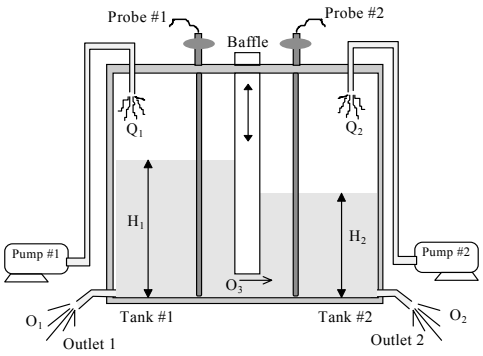
$$A_1 \frac{dH_1}{dt} = Q_1 - a_1\sqrt{H_1} - a_3\sqrt{H_1 - H_2}$$

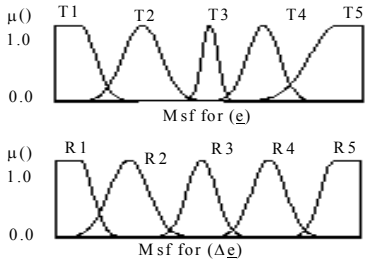
$$A_2 \frac{dH_2}{dt} = Q_2 - a_2\sqrt{H_2} + a_3\sqrt{H_1 - H_2}$$

## Virtual Laboratory Concept using the Coupled Tank system is now available



# The fuzzy membership functions and RBF weights are tuned by the G.A.



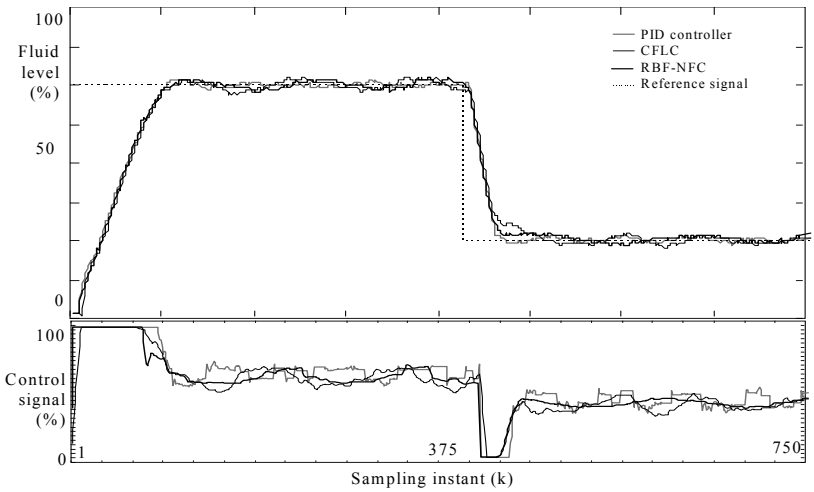




| e / Δe | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|
| R1 | 0.000 | 0.029 | 0.082 | 0.117 | 0.376 |
| R2 | -0.083 | 0.021 | 0.014 | 0.061 | 0.155 |
| R3 | -0.150 | -0.010 | 0.000 | 0.009 | 0.170 |
| R4 | -0.194 | -0.031 | -0.027 | -0.012 | 0.068 |
| R5 | -0.297 | -0.115 | -0.087 | -0.141 | -0.001 |

$$\underline{e}(k) = [e(k)+e(k-1)] \,/\, 2$$
$$\underline{e}(k) = [e(k) - e(k-4) + e(k-1) - e(k-5)] \,/\, 2$$

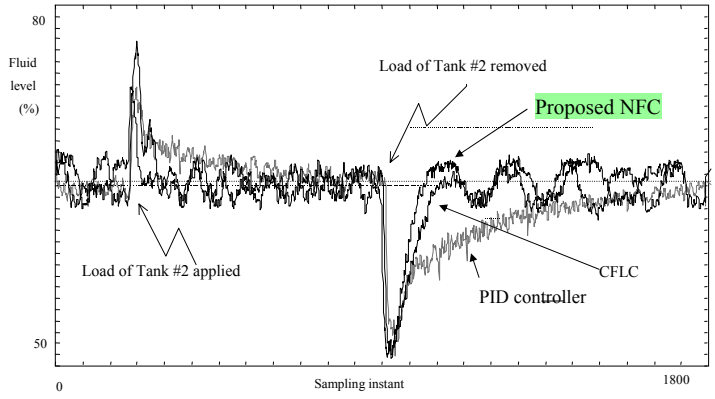
Examples of Application of the neuro-fuzzy controller by G.A.

**Step response of the coupled-tank liquid level control**



Comparison among the 3 systems

Responses of the 3 systems when load disturbances of 20% flow rate of Tank # 2 is applied and then removed.




## Concluding remarks of this research

- Can be easily adapted to many plants
- Can avoid laborious design of FLC
- Performance index can be formulated for various applications and control objectives


"Tuning of a neuro-fuzzy controller by G.A. with application to a coupled-tank liquid-level control system", L.S. Teo, M. Khalid, and R. Yusof, Submitted to Int. Journal on Engineering Applications of AI, Elsevier Science, Vol. 11 (1998) pp. 517-529.

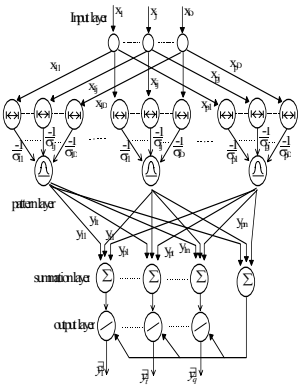
"Tuning of a Neuro-Fuzzy Controller designed by Genetic Algorithms", L.S. Teo, M. Khalid, and R. Yusof, *IEEE* Trans on Systems, Man and Cybernetics, April, 1999, Vol.29, No.2, pp.226-236

## Outcomes of the adaptive Neuro-fuzzy control research by G.A.

- Iterative fitness measurement
- Offline optimization/tuning, i.e. online performance is not guaranteed
- We proposed an adaptive control system with online adaptation based on RBF-NFC and using GRNN as a predictor

## Adaptive Neuro-fuzzy System with Online Learning

Adaptive Hybrid Neuro-fuzzy System with Online Learning using GRNN as a Predictor



## Some information on GRNN

- Developed by Donald Specht (Lockheed)
- Prior to the GRNN, he developed the PNN
- A feedforward neural network
- GRNN is based on localised basis function NN which is based on the probability density functions
- Quite similar in principle to the RBF NN
- The term general regression implies that the regression surface is not restricted to be linear
- If variables to be estimated are future values, the GRNN becomes a predictor as being done in our applications

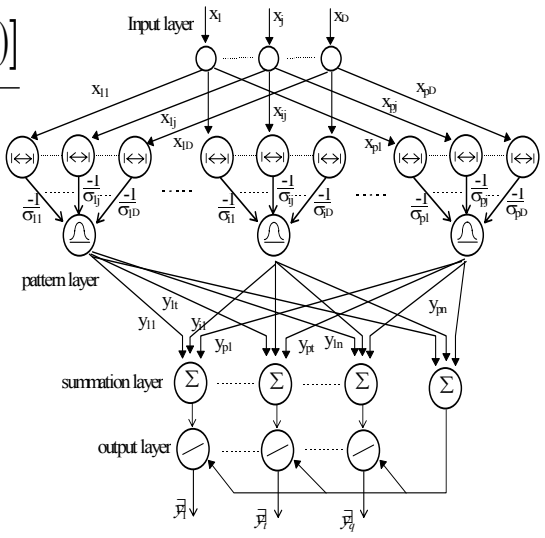
## Computation of GRNN

**Assigning probability to each sample**

$$\hat{y}(x) = E[Y|x] = \frac{\sum_{i=1}^{n}\left[y_i \cdot \exp(d_i)\right]}{\sum_{i=1}^{n}\exp(d_i)}$$

$$d_i = -\frac{(\underline{x}-\underline{x}_i)^T(\underline{x}-\underline{x}_i)}{(\sigma)^2}$$

$$d_i = -\sum_{j=1}^{D}\frac{(x_j - x_{ij})^2}{(\sigma_{ij})^2}$$



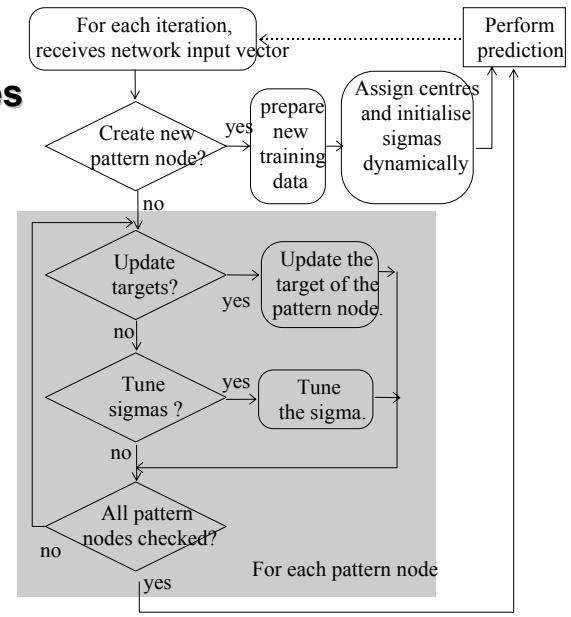
Motivation of this Research

# Using the GRNN as the predictor

- GRNN has been proven to be a good predictor [Chen, 1994, Hyun and Nam, 1995, Marquez and Hill, 1995].
- In many previous applications of the GRNN, the sigma (σ) which is referred to as the smoothing factor in the GRNN algorithm is usually fixed, and thus not applicable in a dynamic environment.
- To date there has not been much work on the application of GRNN for online prediction.

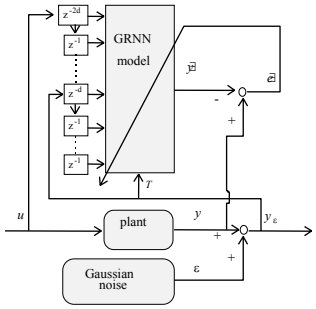
## Proposed 4-GRNN adaptation strategies

- ↗ **Create new pattern nodes**
- ↗ **Dynamic sigma initialization**
- ↗ **Target adjustment**
- ↗ **Sigma tuning by BP**

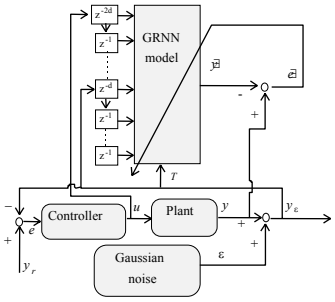



The adaptation flow of the dynamic GRNN model.

## Two approaches using GRNN to model a plant



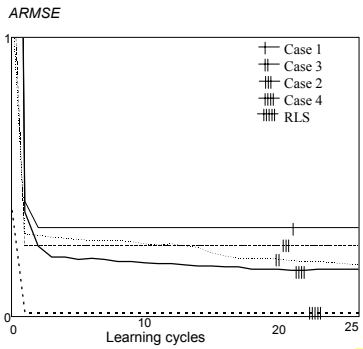

Modelling a plant using GRNN



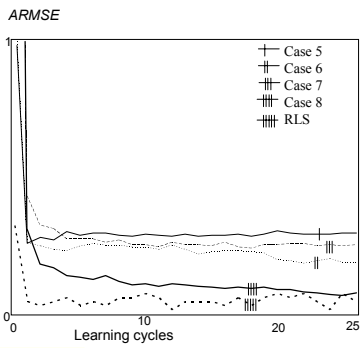

Modelling a plant under controlled using GRNN.

Prediction Error: $ARMSE = \sum_{i}^{L} \left( y_i - \hat{y}_i \right)^2$

## Example of Modelling using the GRNN on a Linear plant without noise and with noise



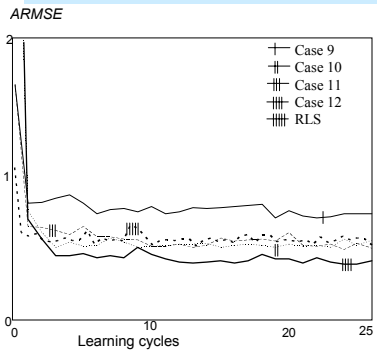

Modelling performance based on *ARMSE* criteria in noise free environment.



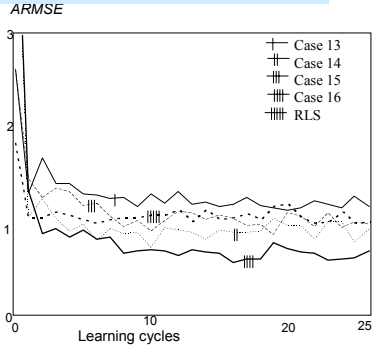

Modelling performance based on *ARMSE* criteria in low noise environment.

* The cases above (1-8) are based on implementation of several strategies in the proposed Adaptive GRNN during modelling

## GRNN performance in modelling improved over the RLS algorithm under heavy noise environment



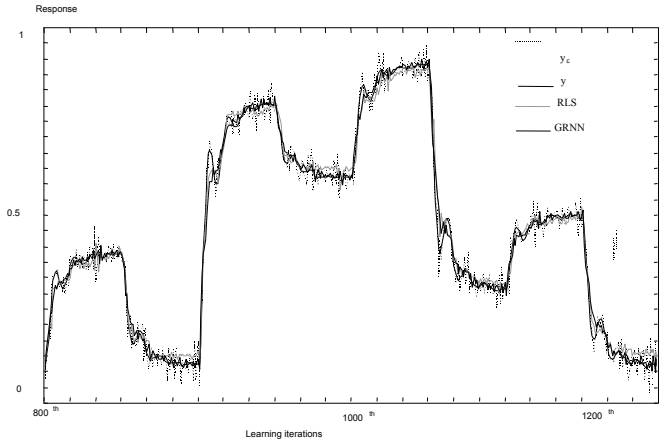

Modelling performance based on *ARMSE* criteria in medium noise environment.




Modelling performance based on *ARMSE* criteria in heavy noise environment.

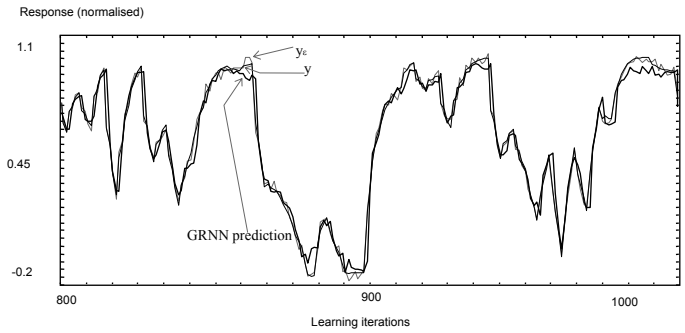
* The cases above (9-16) are based on implementation of several strategies in the proposed Adaptive GRNN during modelling

## Comparison of Modelling performance on a linear plant between GRNN (best case) and RLS



## Using GRNN to model a nonlinear plant

$$y(k+1) = \frac{y(k)y(k-1)[2.5 + y(k-1)]}{1 + y^2(k) + y^2(k-1)} + 2.0\frac{e^{-u(k)} - 1}{e^{-u(k)} + 1} + \varepsilon(k)$$



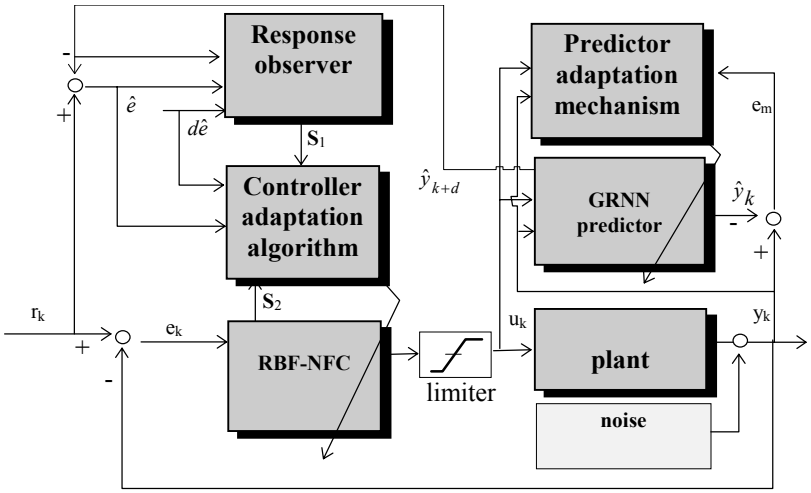

GRNN prediction with Gaussian noise amplitude of 0.05.

L.S. Teo, M. Khalid, and R. Yusof, "Adaptive GRNN for modeling of dynamic plants", Proc. Of Inst. of Mech. Engineers, Vol. 213, Part 1, pp. 275-287, 1999.

## *Advantages*
## GRNN as dynamic process model

- ↗ instant / fast learning-- stored sample, regression surface
- ↗ allow continuous tuning
- ↗ incremental network size
- ↗ model stability is guaranteed
- ↗ does not converge to local minimum, approaching Bayes-optimal decision boundaries

## Adaptive hybrid control system using RBF as the NFC and GRNN as the predictor




The proposed adaptive hybrid control system.

## The NFC adaptation

- **Based on GRNN prediction - preventive correction**
- **Applied to consequents of the fuzzy control rules**
- **Adaptation actions of this controller:**
  - ↗ control actions tuning
  - ↗ control actions trimming
  - ↗ RBF-NFC output gain adjustment

## Adaptation of the control actions

$$\left.\begin{aligned}\delta(k) &= \eta \cdot g[\hat{e}(k), \Delta\hat{e}(k)] \cdot COC \\ \Delta w_{ij}(k) &= f_{ij}(k) \cdot \delta(k) \\ w_{ij}(k) &= w_{ij}(k-1) + \Delta w_{ij}(k)\end{aligned}\right\} \text{Adaptation algorithm}$$

$$coc = f(\vec{e}) = p \cdot \vec{e}(k)$$

$$g[\hat{e}(k), \Delta\hat{e}(k)] = \frac{1.0}{1.0 + \exp[-c_1 \cdot \hat{e}(k) \cdot \Delta\hat{e}(k)]}$$

## Trimming of the control actions

*for r=1 to ξ*

*for s=1 to ς*

$$w_{mrs} = [1 - f_s\{\Delta\hat{e}(v)\} / r] \cdot w_{mrs}$$

$$f_s\{\Delta\hat{e}(v)\} = \phi_s \cdot \Delta\hat{e}(v)$$

## Scaling the control signal gain

$$G_{u\_scaled} = d \cdot G_{u\_old}$$

and $$G_{u\_new} = (1-\alpha) \cdot G_{u\_old} + \alpha\, G_{u\_scaled}$$

therefore $$G_{u\_new} = G_{u\_old} \cdot [(1-\alpha) + \alpha \cdot d]$$

as counter action $$w_{ij\_new} = w_{ij\_old} \cdot [(1-\alpha) + \alpha / d]$$

$$d = 1 + \beta \quad \text{if } AMW < \varpi_1$$

$$d = 1 - \beta \quad \text{if } AMW > \varpi_2$$

$$d = 1 \quad \text{else}$$

## Experiments conducted

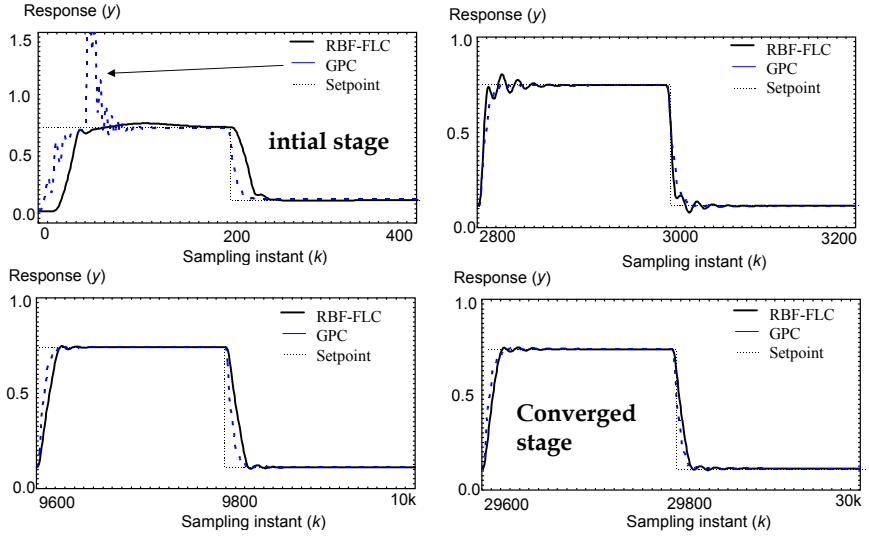
- **GRNN learns the process knowledge online**
- **No knowledge of control actions is used at initial stage**
- **3 different plants**
  - Comparison study to GPC control based on a linear plant
  - Application to an unstable-nonlinear plant
  - Control of a single link manipulator

# Comparative study on a linear plant

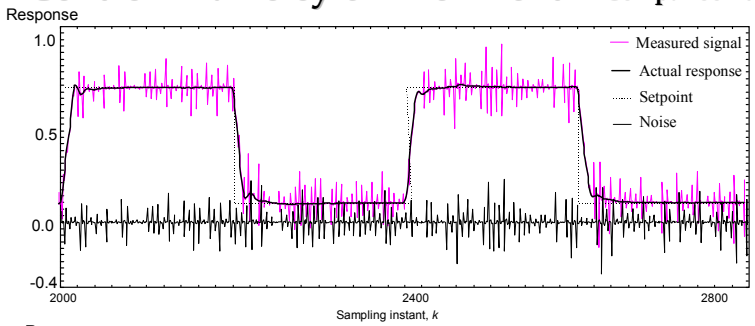
$$A(z^{-1})y(k) = B(z^{-1})u(k-d) + C(z^{-1})\varepsilon(k)$$

$$A(z^{-1}) = 1.0 - 1.5z^{-1} + 0.7z^{-2}$$
$$B(z^{-1}) = 1.0 + 0.5z^{-1}$$
$$C(z^{-1}) = 1.0 - 1.0z^{-1} + 0.2z^{-2}.$$

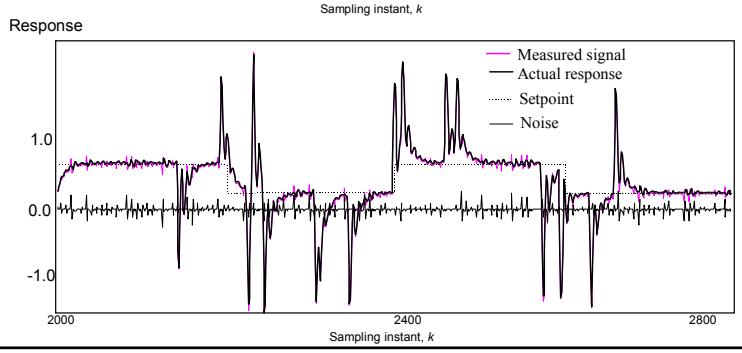
# Step response (NFC vs GPC)



## Control in a noisy environment ~ Comparison to GPC




NFC




GPC

## Experiments on an unstable-nonlinear plant

$$\dot{x}(k) = 0.5\frac{e^{0.6|x(k-1)|.\{x(k-1)-x(k-2)\}} - 1.0}{e^{0.6|x(k-1)|.\{x(k-1)-x(k-2)\}} + 1.0} + 0.1u^3(k-1) + \varepsilon(k)$$

$$x(k) = x(k-1) + \dot{x}(k)$$
$$y(k) = x(k)$$

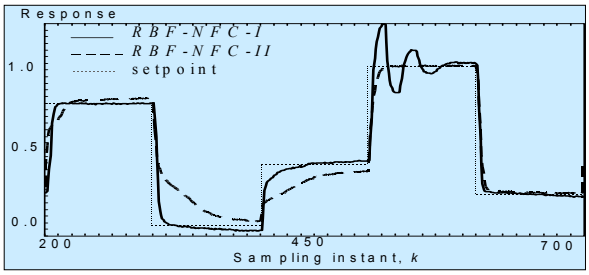
**2 configuration of RBF-NFC:**

**RBF-NFC-I : e-Δe**

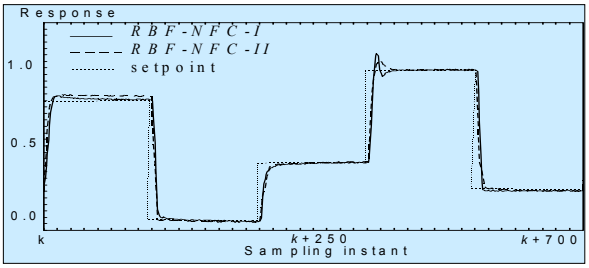
**RBF-NFC-II: e-y**

# Transient response of the nonlinear plant

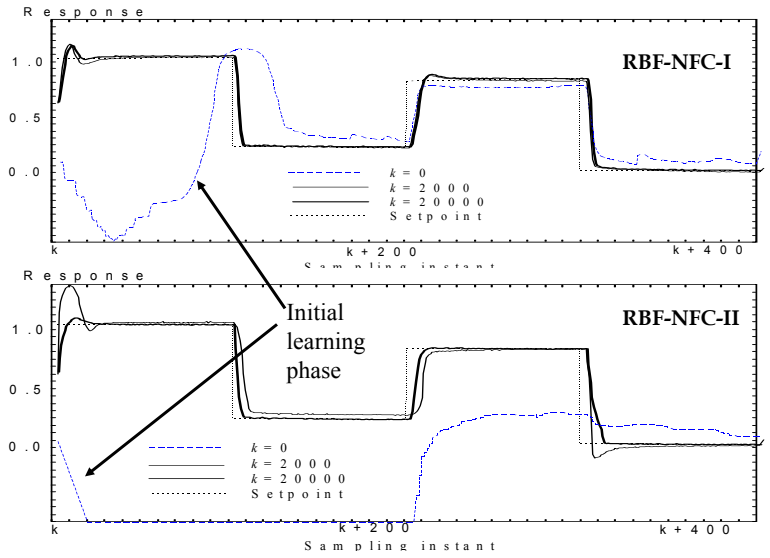
**Initial stage**



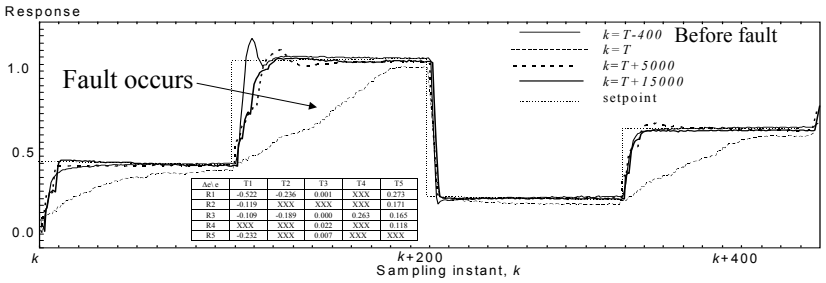

**Learned stage**



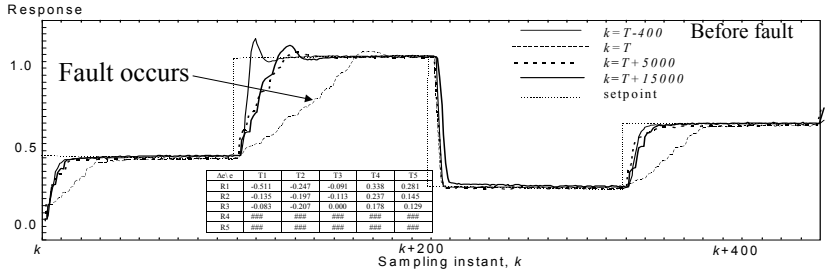

**Example of Adaptation as means of correcting the faulty control rules using the GRNN - Fault is simulated by cancelling some rules of the NFC: 2 cases**



## Adaptation as means of compensating controller faults

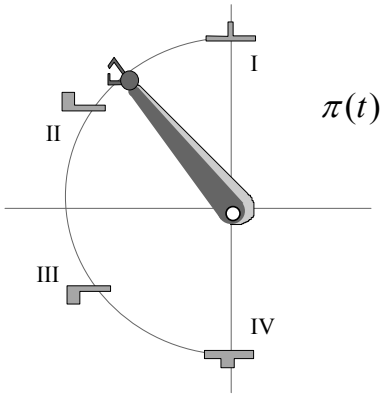



| Δe\ e | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|
| R1 | -0.522 | -0.236 | 0.001 | XXX | 0.273 |
| R2 | -0.119 | XXX | XXX | XXX | 0.171 |
| R3 | -0.109 | -0.189 | 0.000 | 0.263 | 0.165 |
| R4 | XXX | XXX | 0.022 | XXX | 0.118 |
| R5 | -0.232 | XXX | 0.007 | XXX | XXX |




| Δe\ e | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|
| R1 | -0.511 | -0.247 | -0.091 | 0.338 | 0.281 |
| R2 | -0.135 | -0.197 | -0.113 | 0.237 | 0.145 |
| R3 | -0.083 | -0.207 | 0.000 | 0.178 | 0.129 |
| R4 | ### | ### | ### | ### | ### |
| R5 | ### | ### | ### | ### | ### |

## Application to a single-link manipulator



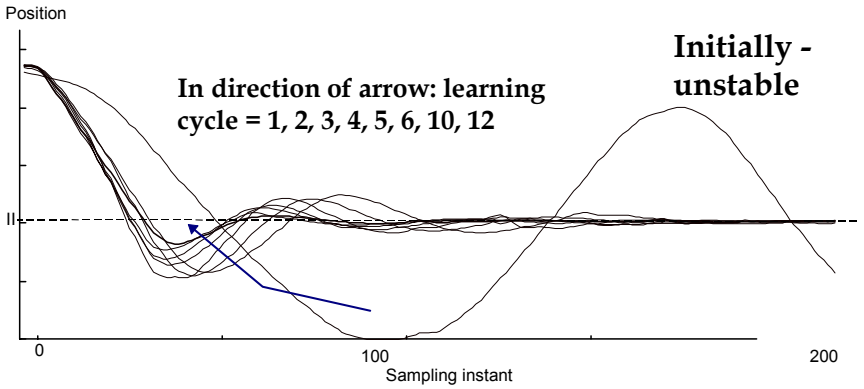

$$\pi(t) = ml^2\ddot{\theta}(t) + v\dot{\theta}(t) + mgl\cos\left(\theta(t)\right)$$

$$\dot{x}_1(t) = x_2(t)$$

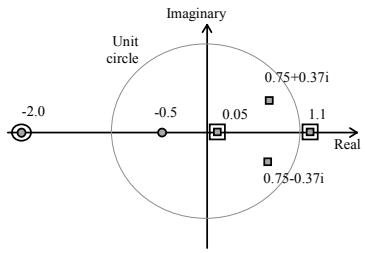
$$\dot{x}_2(t) = \frac{-v}{ml^2}x_2(t) - \frac{g}{l}\cos\left(x_1(t)\right) + \frac{1}{ml^2}u(t)$$

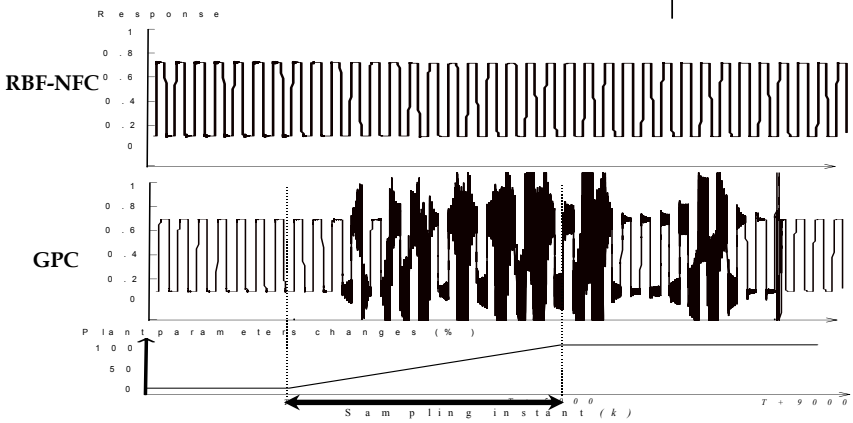
$$y(t) = x_1(t) + \varepsilon(t)$$

# Improvement of the transient response




# Response to changes in plant dynamics



## Proposed a two-stage combinatorial design approach

**Due to imperfectness of evaluation model**

**1 --- offline configuration by GA**

**2 --- online tuning by the adaptive NFC systems**

$$y(k)=\frac{g\cdot y(k-1)}{1.0+a\cdot y^{2}(k-n)}+b\cdot\left[y(k-1)-y(k-2)\right]\cdot u(k-1)+c\cdot u^{d}(k-1)+\varepsilon(k)$$

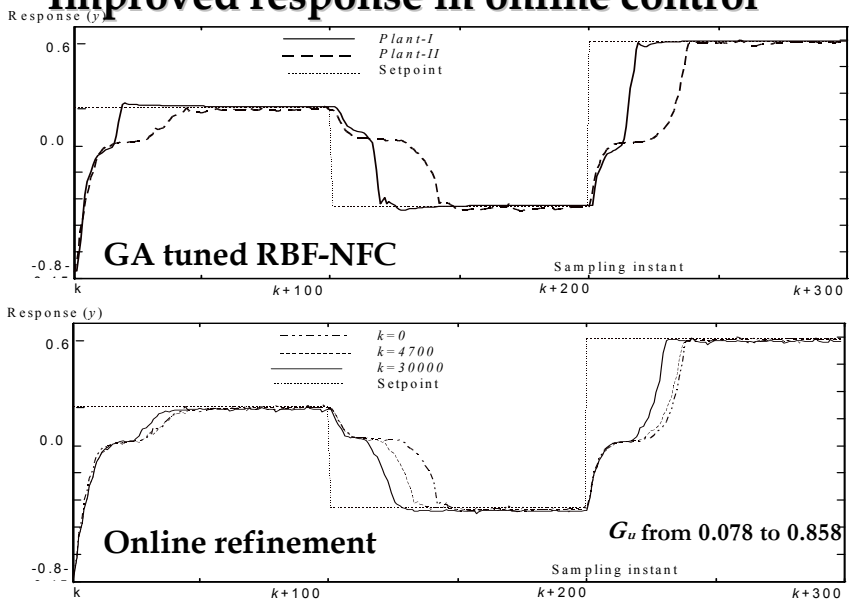
***Plant-I*** : ***g=1.0, a=1.0, n=1, b=0.0, c=1.0, d=3***

***Plant-II*** : ***g=1.0, a=51.0, n=2, b=0.0, c=0.2, d=3***

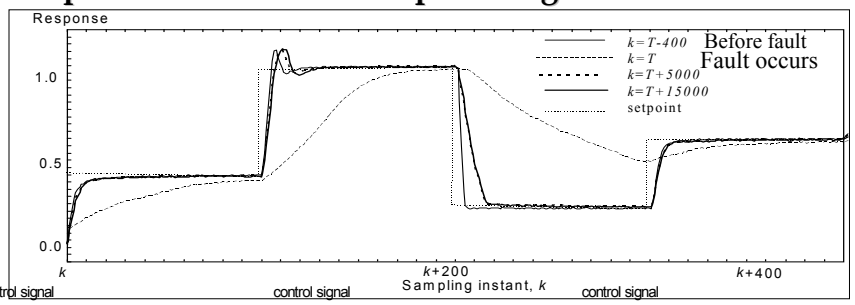
***Plant-III*** : ***g=0.9, a=0.0, n=2, b=0.4, c=0.3, d=1***

**Example of Result**

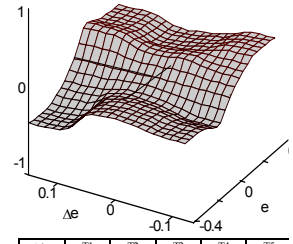
## Improved response in online control



# Adaptation as means of compensating the controller faults

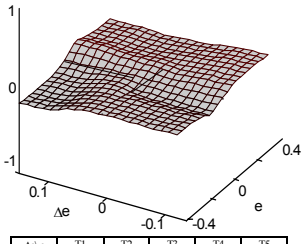



control signal




| Δe\ e | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|
| R1 | -0.492 | -0.257 | -0.031 | 0.402 | 0.285 |
| R2 | -0.111 | -0.181 | -0.035 | 0.243 | 0.140 |
| R3 | -0.106 | -0.192 | 0.000 | 0.217 | 0.170 |
| R4 | -0.129 | -0.228 | -0.023 | 0.311 | 0.207 |
| R5 | -0.217 | -0.372 | 0.013 | 0.161 | 0.366 |

control signal




| Δe\ e | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|
| R1 | -0.492 | -0.257 | -0.031 | 0.402 | 0.285 |
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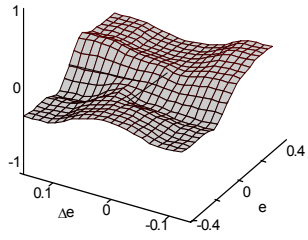
| R4 | -0.129 | -0.228 | -0.023 | | 0.207 |
| R5 | -0.217 | -0.372 | 0.013 | 0.161 | 0.366 |

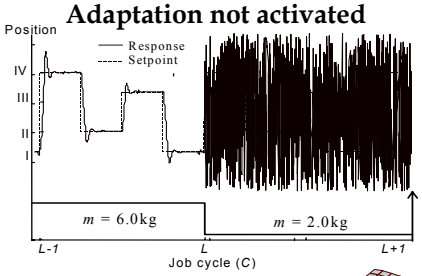
control signal



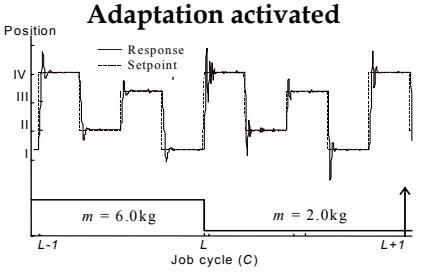

| Δe\ e | T1 | T2 | T3 | T4 | T5 |
|---|---|---|---|---|---|
| R1 | -1.000 | -0.966 | -0.132 | 0.803 | 0.641 |
| R2 | -0.292 | | -0.231 | 0.446 | 0.198 |
| R3 | -0.238 | -0.540 | 0.000 | 0.395 | 0.188 |
| R4 | -0.336 | -0.579 | -0.109 | | 0.237 |
| R5 | -0.902 | -0.786 | -0.064 | 0.351 | 0.899 |

# Adaptation when the load changes happened

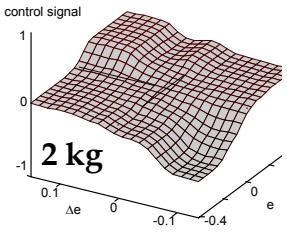
## Adaptation not activated



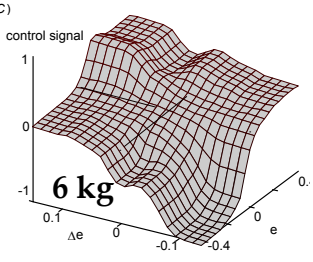

## Adaptation activated



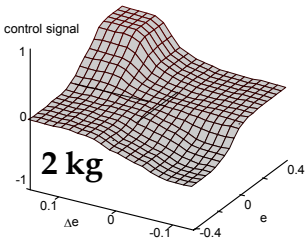

control signal




control signal




control signal



## Overall concluding remarks

- Ahead -- integration, hybrid & combination
- RBF-NFC = NN + FLS
- Learning by using evolutionary method - GA
  - ↗ avoids laborious tuning of FLC parameters
  - ↗ generates near optimal solutions
  - ↗ applicable to many types of control systems
  - ↗ limitation: evaluation model

## Overall concluding remarks

- Dynamic GRNN model
  - ↗ 4 adaptation strategies have been proposed
  - ↗ perform better than ERLS in noisy condition
  - ↗ fast learning and adaptation
  - ↗ structural and computational effective

# Overall concluding remarks

- Adaptive hybrid control system
  - ↗ hybrid of GRNN & NFC
  - ↗ 3 controller adaptation steps --> proposed
  - ↗ Better perf. than the GPC
  - ↗ Fast learning and good response observed
  - ↗ able to correct improper control actions & sustaining stable control
- Two-stage combinatorial design approach
  - ↗ 2 complementary RBF-NFC learning methods

For more detail information, please refer to the following papers:


”Tuning of a neuro-fuzzy controller by G.A. with application to a coupled-tank liquid-level control system", L.S. Teo, M. Khalid, and R. Yusof, Submitted to Int. Journal on Engineering Applications of AI, Elsevier Science, Vol. 11 (1998) pp. 517-529.

"Tuning of a Neuro-Fuzzy Controller designed by Genetic Algorithms", L.S. Teo, M. Khalid, and R. Yusof, *IEEE* Trans on Systems, Man and Cybernetics, April, 1999, Vol.29, No.2, pp.226-236

L.S. Teo, M. Khalid, and R. Yusof, “Adaptive GRNN for modeling of dynamic plants”, Proc. Of Inst. of Mech. Engineers, Vol. 213, Part 1, pp. 275-287, 1999.

L.S. Teo, M. Khalid, R. Yusof and S. Omatu “Adaptive Neuro-Fuzzy Control Systems by RBF and GRNN neural networks”, Int. Journal of Intelligent and Robotics System, Kluwer Academics, Vol. 23 (Special Issue), December, 1998.

# Further works

- **Parallel GA hardware**
- **Fasten the evaluation process, e.g. incorporating chaos theory and advance clustering algorithms**
- **Global GA stability and convergence property**
- **Advance evolutionary paradigm, e.g. incremental GA, run-time flexible programs**
- **Online adaptation - antecedents of FLC - neural clustering**
- **Real-time application using the Adaptive Neuro-fuzzy system**
- **Supervisory mechanism using ES, for more complex industrial control**

## [5] Examples of research at the university

5.1: Differences among Postgraduate and Undergraduate Research

5.2: Example of a PhD Research Work

5.3: Example of a Masters Research Work

5.4: Example of a Bachelor's Research/Project

5.5: Preparations for an undergraduate final year project

ICA2000

# ADAPT
# An Intelligent Software for the Diagnosis of Power Transformers

by

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Syed Fuad Syed Zain and Aizam Talib

+Tenaga Nasional Berhad Research

## Presentation Layout

- Project Background/Objective
- Transformer Diagnosis
- The ADAPT Software
- Design Advantages using Fuzzy Logic
- Fuzzy Ratio Method
- Example of Interpretations
- Conclusion

# Project Background

### Transformer

**The power transformer is a main components in a power transmission network, and its correct functioning is vital the the network operations.**

### Problem

**Major faults in transformers cause extensive damage, interruption of electricity supply and result in large revenue losses to power utility company.**

# Newspaper Report

***6th February 2000***


Sub-station transformer explodes in North Port

PORT KLANG: A transformer in Tenaga National Bhd's intake sub-station at North Port here exploded and caught fire yesterday.

No injuries were reported in the 3.30pm incident.

The incident, however, did not affect port operations and only disrupted power supply to Wisma Kastam and certain parts of Pandamaran Village, said Syed Hidzam Osman, per-

An Explosion of Transformer at a TNB Substation due to Improper Maintenance

*13 March 2000*

Damage Cost >RM2million

## Transformer Blast at Klang due to improper maintenance

Estimated losses at RM4 million - TNB

TNB prepared to handle situation

FROM PAGE ONE

inter-connected back-up system and contingency plan," said Azman.

Fortunately, he said, most of the industries were closed today and tomorrow, allowing TNB to carry out repairs at the affected facility.

TNB expects to install a new transformer and supporting equipment after police and the Chemistry Department have completed their investigations.

Azman said TNB workers would have their hands full on Monday when the industries resumed business.

"But we will be prepared to handle the situation by installing mobile power supply units as a temporary measure," he said.

Azman did not dismiss sabotage at the facility as there had been three break-ins previously where thieves carted away RM80,000 worth of copper wires and parts.

As the fenced facility is not manned by security staff, TNB relies on spot checks and tip-offs from the public of any trespassers.

Klang police chief Assistant Commissioner Kam Peng said police had recorded statements from several eye-witnesses and TNB staff. They were now awaiting the chemist's report.

"We want to ensure that there is no foul play," he said, adding that several Special Branch officers were assisting in the investigations.

Kam said police were initially informed of an explosion, believed to be from a bomb.

Port Klang Fire and Rescue Department operations commander Assistant Superintendent Charles Gomes said they received a call from the public at 10.45am.

AT ITS HEIGHT ... A fireman battling to contain the flames. — Pictures by Koh Kian Giap

## Project Background

- In Malaysia there are over one thousand power transformers in service at Tenaga Nasional Berhad (TNB), each of these transformers will undergo routine checks using the Dissolved Gas Analysis Method (DGA)
- This is needed as transformers are highly expensive and failure in the transformers may result in disruption of power supply to industries and consumers which could result in a substantial amount of revenue losses for TNB

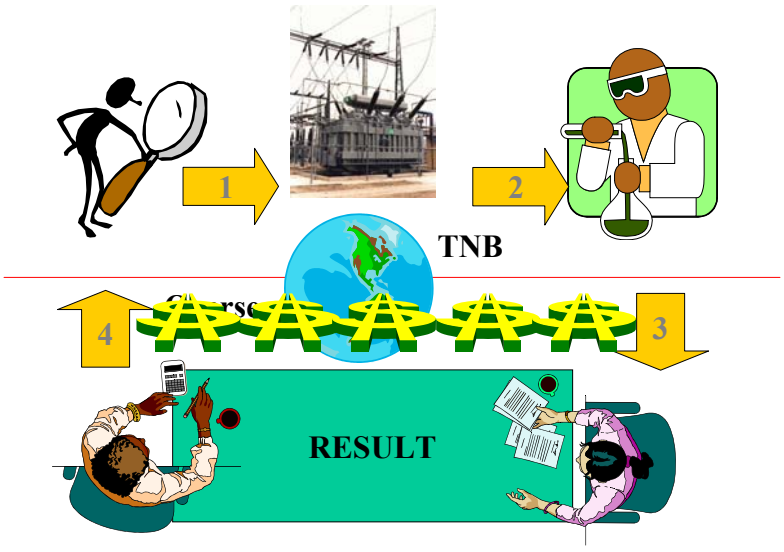
## Current Problem faced by TNB

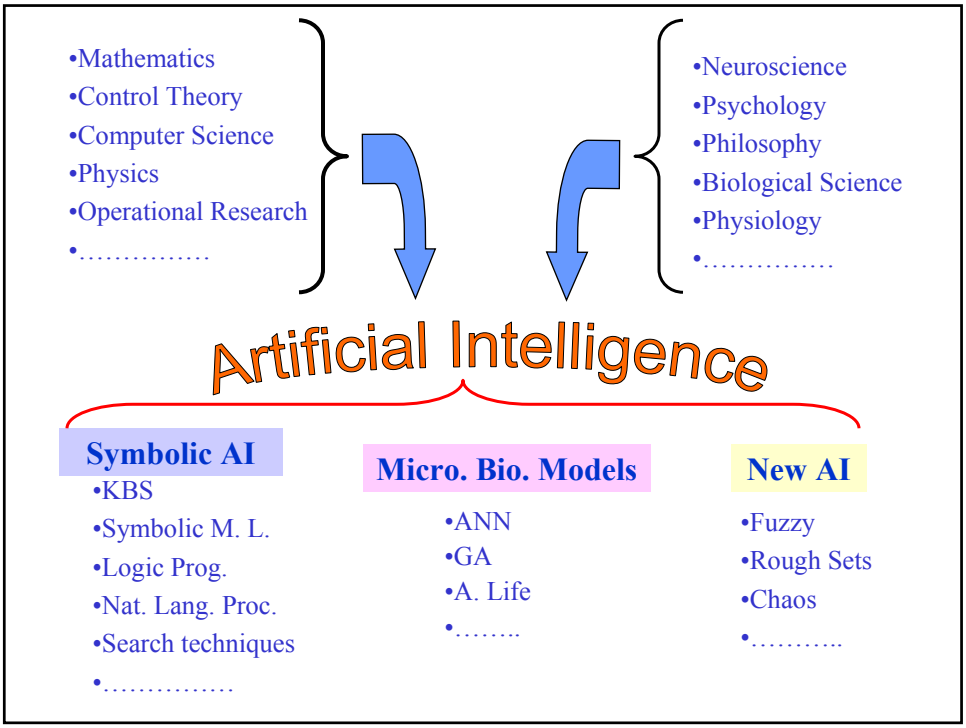
- Fault diagnostic of an oil insulated transformer needs a lot of expertise and experience.
- Conventionally, diagnosis of transformer's faults are done by the foreign experts which is a time consuming and expensive task because there is a lack in local expertise to interpret difficult or inconclusive DGA test result.
- Different manufacturer's specifications, trends of operations and climatic conditions may exhibit different characteristics and problems.

# Transformer Diagnosis

- Major power transformers are filled with a fluid that serves as a dielectric media, an insulator and as a heat transfer agent.
- Normal
  - slow degradation of the mineral oil to yield certain gases.
- Electrical fault
  - gases are generated at a much more rapid rate.
- Different patterns of gases are generated due to different intensities of energy dissipated by various faults.
- The gases present in an oil sample make it possible to determine the nature of fault by analysing the gas types and their amount.

# Existing Process

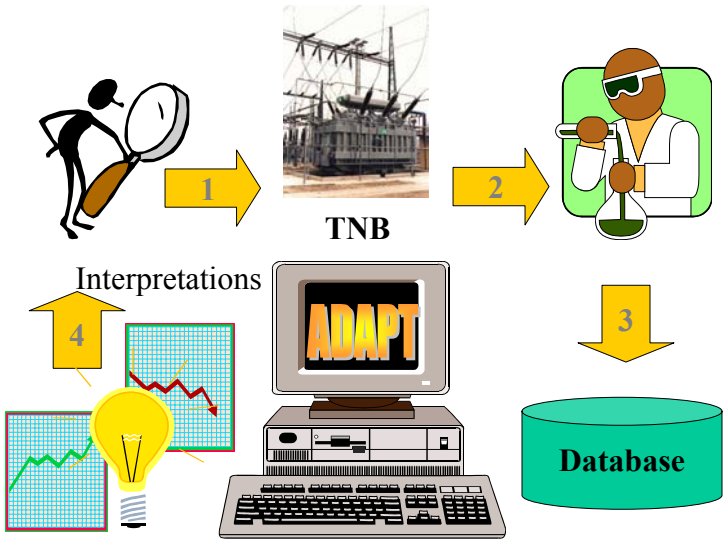





# Our Intelligent Solution - ADAPT

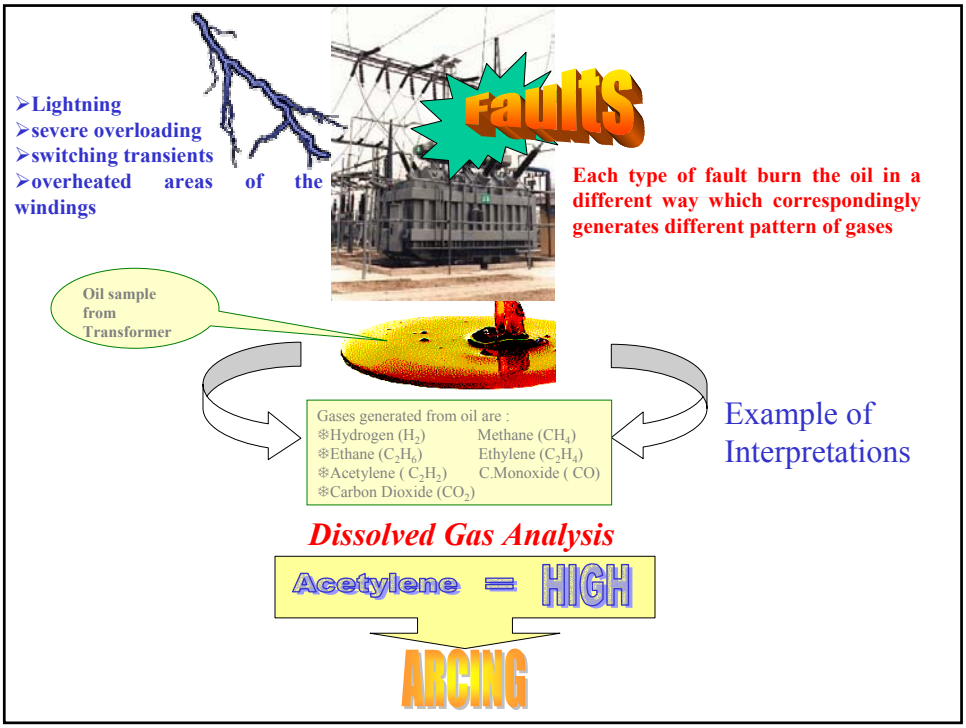
- An Intelligent diagnostic software has been developed to diagnose power transformers
- The software can be used for monitoring, analysing and diagnosing faults in power transformers
- The software consists of AI techniques such as Fuzzy Logic/Neural Networks/etc which mimic human intelligence to solve the complex diagnostic problems

# ADAPT Interpretation Process



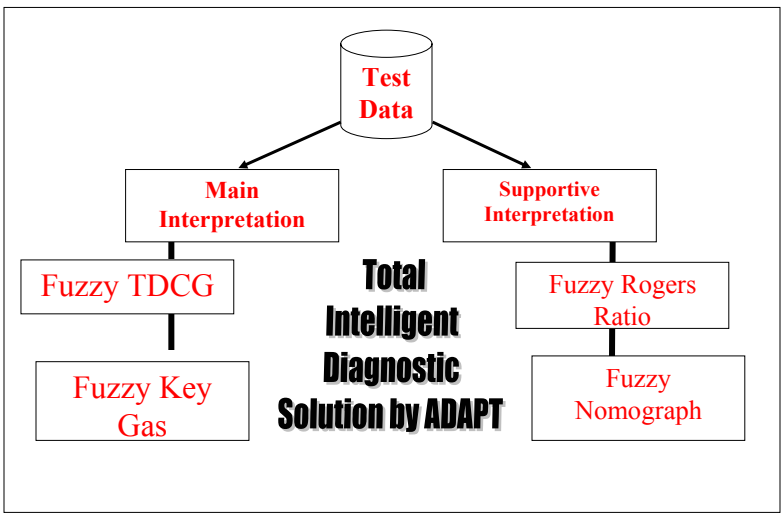

# Software Scope/Objectives

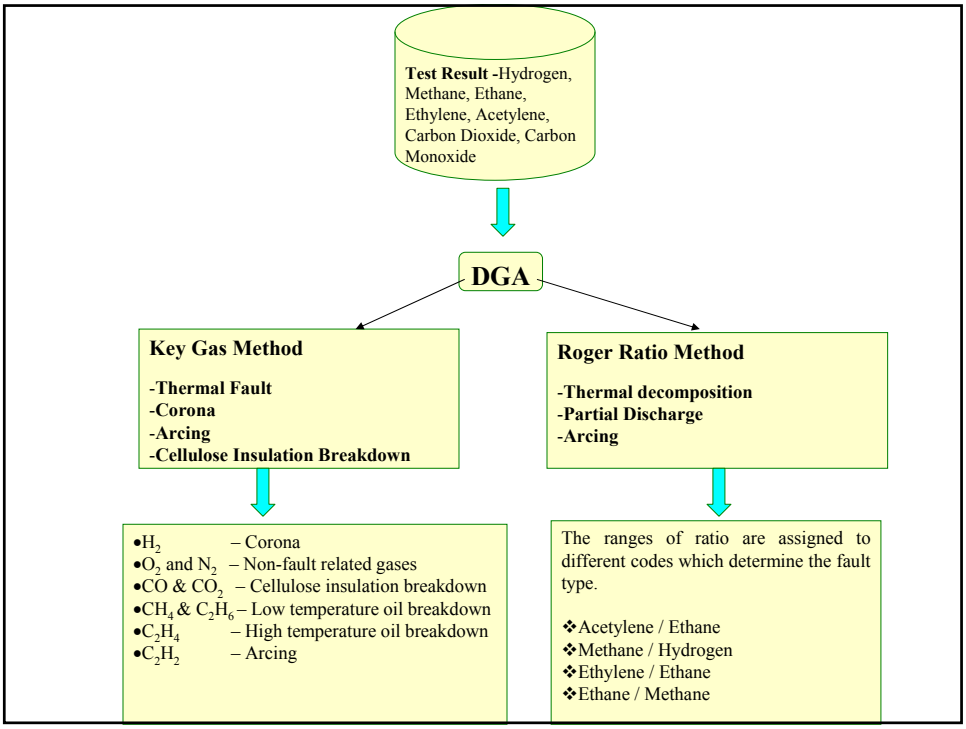
- To detect and predict faults in transformer using the AI technique such as Fuzzy Logic and Neural Networks.
- To automate the process of analysing the oil test result, record retrieving and record keeping of large volume of transformer information.
- To automate the process of human expert interpretation for the DGA test result in order to provide advance warning of faults in transformer.
- To monitor and predict the condition of transformers in order to avoid the improper use of transformer.




# DGA Method

## ~Tranformer Diagnosis Methods



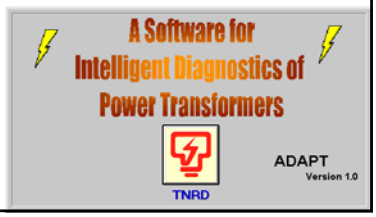


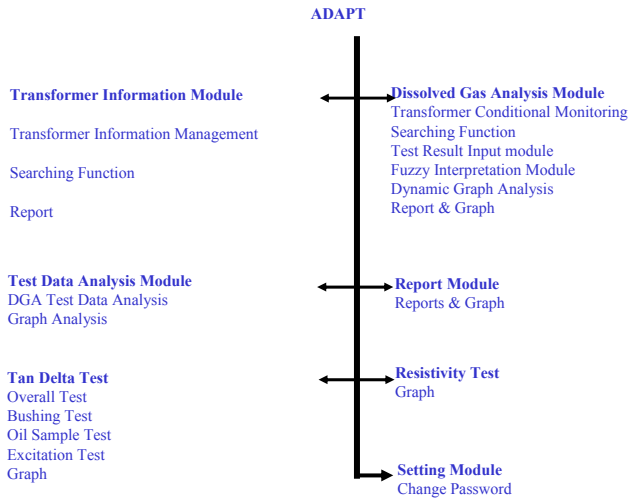

# Features of the ADAPT Software

- Visual Basic 5 & MS Access
- Icon-Based Graphical User Interface
- Database Management System
- Multi-Criteria Searching Function
- Client-Server Application
- Plot Various Graphs and Reports
- Fuzzy Integrated Diagnostic System

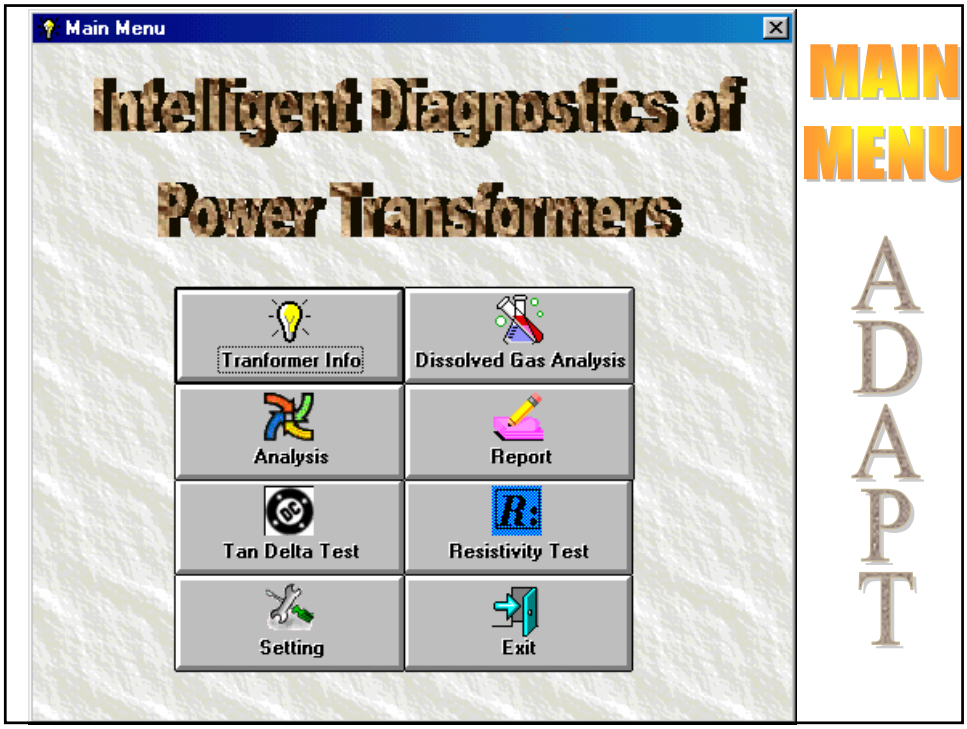
# ADAPT MODULES

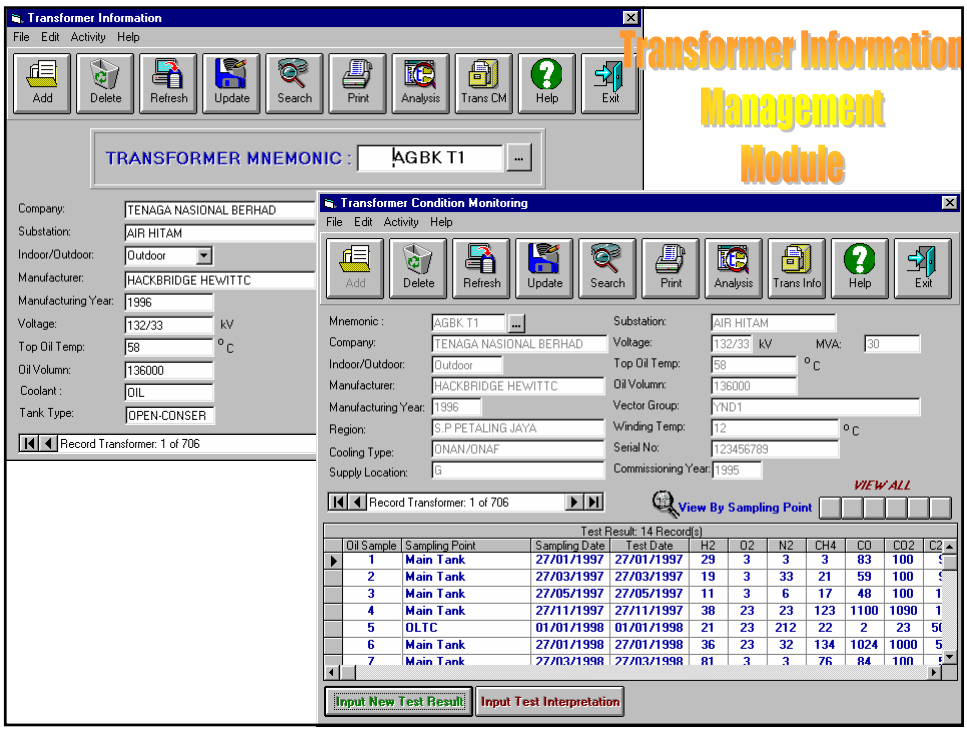
- Transformer Information Management Module
- Dissolved Gas Analysis (DGA) Module
- Analysis Module
- Tan Delta Test Module
- Resistivity Test Module

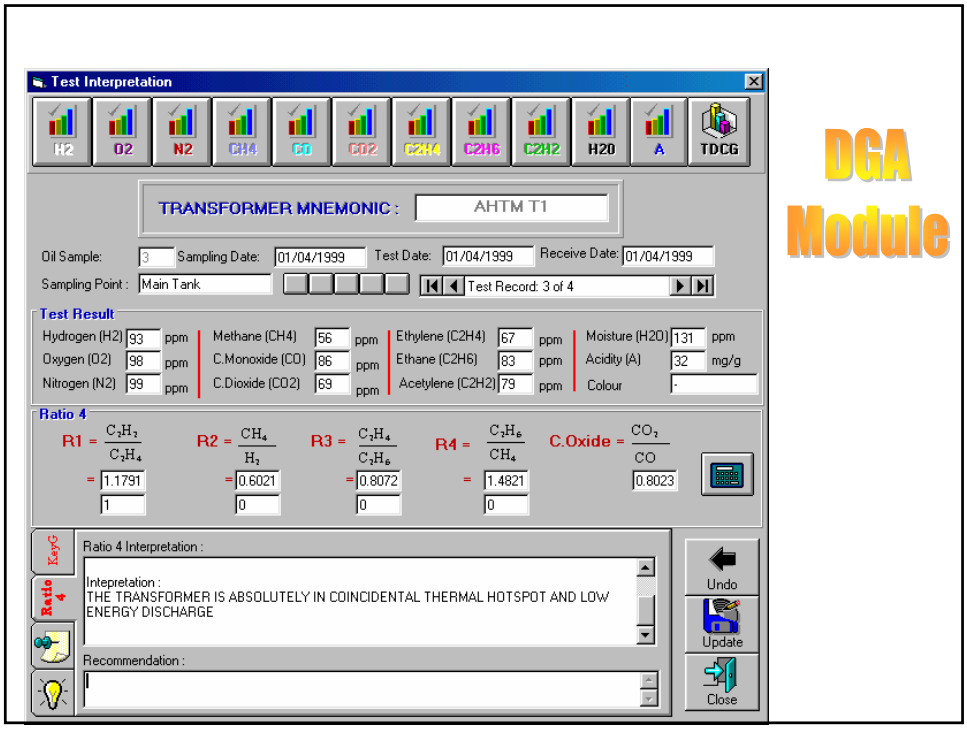


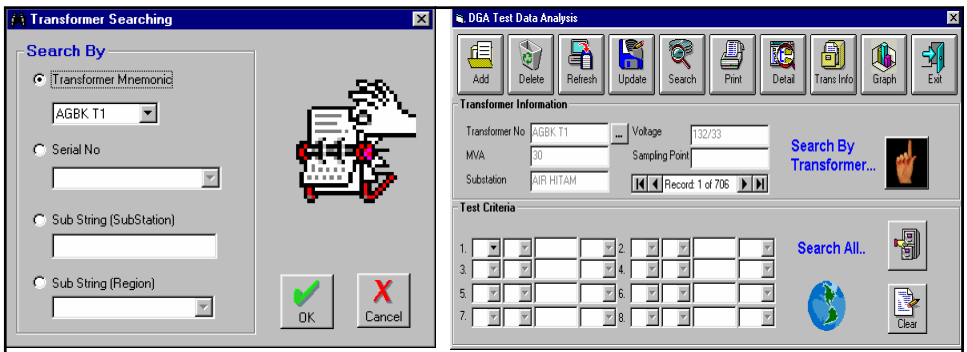

ADAPT STRUCTURE


Main Menu
Intelligent Diagnostics of Power Transformers
Tranformer Info
Dissolved Gas Analysis
Analysis
Report
Tan Delta Test
Resistivity Test
Setting
Exit
MAIN MENU
ADAPT

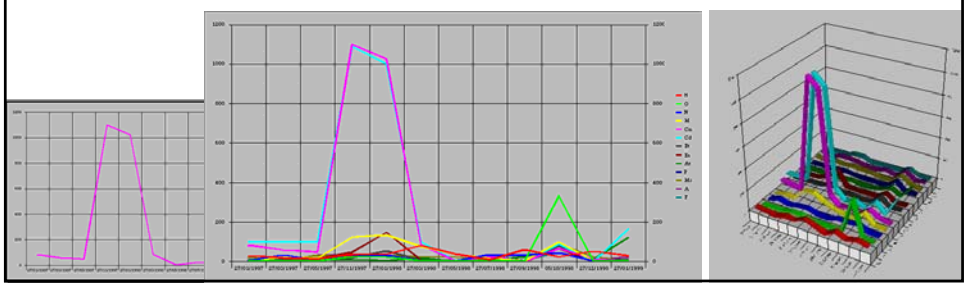

Transformer Information
File Edit Activity Help
Add Delete Refresh Update Search Print Analysis Trans CM Help Exit
TRANSFORMER MNEMONIC : AGBK T1
Company: TENAGA NASIONAL BERHAD
Substation: AIR HITAM
Indoor/Outdoor: Outdoor
Manufacturer: HACKBRIDGE HEWITTC
Manufacturing Year: 1996
Voltage: 132/33 kV
Top Oil Temp: 58 °C
Oil Volumn: 136000
Coolant : OIL
Tank Type: OPEN-CONSER
Record Transformer: 1 of 706
Transformer Information Management Module
Transformer Condition Monitoring
File Edit Activity Help
Add Delete Refresh Update Search Print Analysis Trans Info Help Exit
Mnemonic : AGBK T1
Company: TENAGA NASIONAL BERHAD
Indoor/Outdoor: Outdoor
Manufacturer: HACKBRIDGE HEWITTC
Manufacturing Year: 1996
Region: S.P PETALING JAYA
Cooling Type: ONAN/ONAF
Supply Location: G
Substation: AIR HITAM
Voltage: 132/33 kV MVA: 30
Top Oil Temp: 58 °C
Oil Volumn: 136000
Vector Group: YND1
Winding Temp: 12 °C
Serial No: 123456789
Commissioning Year: 1995
VIEW ALL
Record Transformer: 1 of 706
View By Sampling Point
Test Result: 14 Record(s)
Oil Sample | Sampling Point | Sampling Date | Test Date | H2 | O2 | N2 | CH4 | CO | CO2
1 Main Tank 27/01/1997 27/01/1997 29 3 3 3 83 100
2 Main Tank 27/03/1997 27/03/1997 19 3 33 21 59 100
3 Main Tank 27/05/1997 27/05/1997 11 3 6 17 48 100
4 Main Tank 27/11/1997 27/11/1997 38 23 23 123 1100 1090
5 OLTC 01/01/1998 01/01/1998 21 23 212 22 2 23
6 Main Tank 27/01/1998 27/01/1998 36 23 32 134 1024 1000
Input New Test Result
Input Test Interpretation

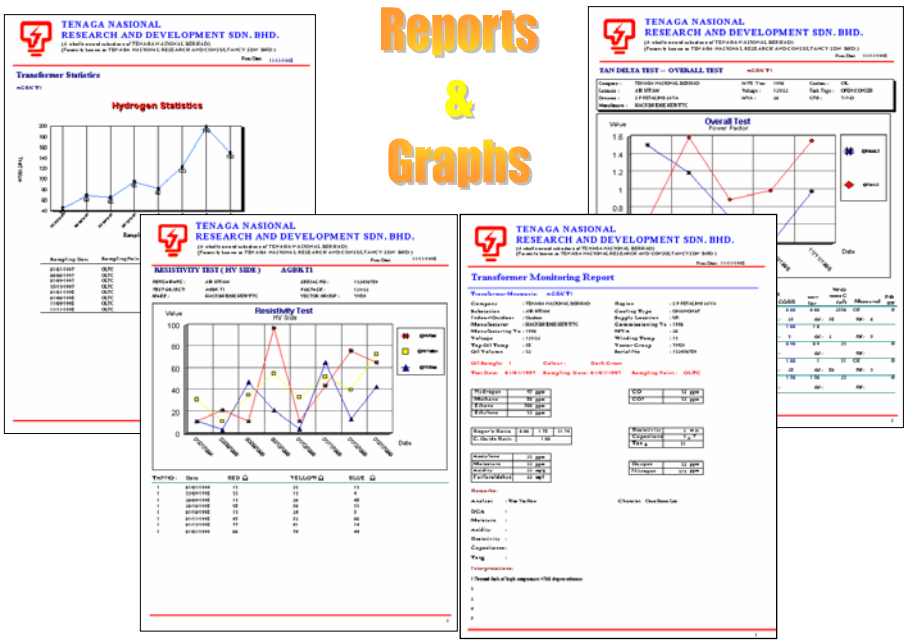



# DGA Module




# Software Features



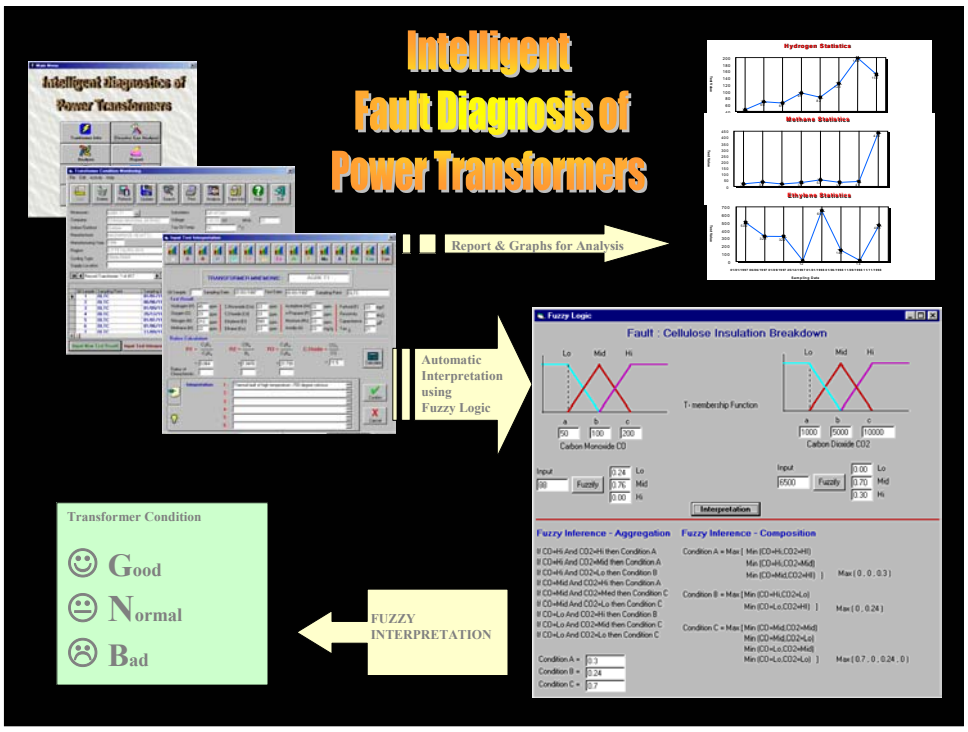



# Advantages of Fuzzy Logic

- Can provide human-like interpretation
  - Eg. The transformer is most probably in the ARCING condition
- Human experience can be incorporated into the fuzzy knowledge base in natural language form.
  - Eg. If Acetylene=high then Arcing
- Can handle imprecise and uncertainty value
  - Data measurement
  - Linguistic imprecision

# Fuzzy Design Methodology

- Identify the fuzzy input and output variables ~gases
- Quantize each of the fuzzy variables into smaller subsets appropriately.
- Set up a fuzzy inference rule base
- Select a fuzzy compositional operator, usually the max-min operator is used.
- Select a defuzzification procedure.



# Fuzzy Rogers Ratio

- **Rogers Ratio Method published by R. Rogers in 1978 use Acetylene/Ethylene, Methane/Hydrogen, Ethylene/Ethane and Ethane/Methane to generate a four digit different ratio codes that can be used to determine the corresponding fault**

Example :

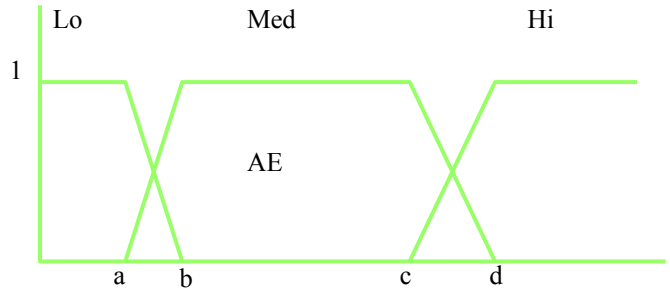
0010 ⟶ Insulated conductor overheating

1001 ⟶ Coincidental thermal hotspot and low energy discharge

# Real variable --> Linguistic Variable

| | | |
|---|---|---|
| ***AE = Acetylene / Ethane*** | ***Lo*** | ***AE < 0.1*** |
| | ***Med*** | ***0.1 <= AE<=3.0*** |
| | ***Hi*** | ***AE >3.0*** |
| *MH = Methane / Hydrogen* | *Lo* | *MH <0.1* |
| | *Med* | *0.1 <= MH <= 1.0* |
| | *Hi* | *1.0 <= MH <= 3.0* |
| | *VHi* | *MH > 3.0* |
| *EE = Ethane / Ethylene* | *Lo* | *EE < 1.0* |
| | *Med* | *1.0 <=EE <= 3.0* |
| | *Hi* | *EE > 3.0* |
| *EM = Ethane / Methane* | *Lo* | *EM < 1.0* |
| | *Hi* | *EM >= 1.0* |

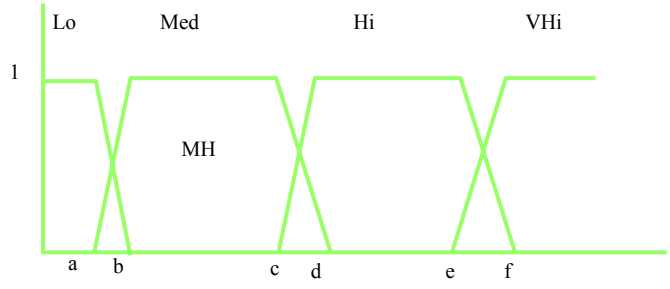
# Fuzzification of the A/E ratio




a= 0.095 b=0.105 c= 2.85 d= 3.15

Fuzzy membership function for classifying Acetylene / Ethane ratio for the Roger 4-Ratio

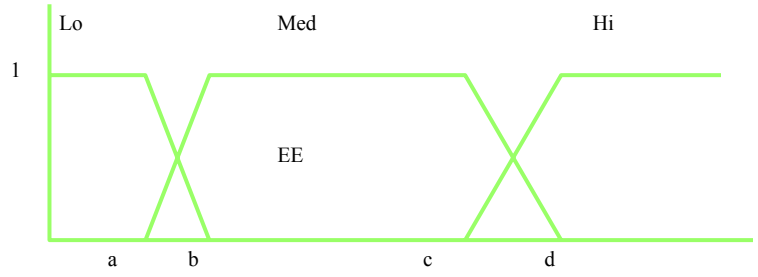
# Fuzzification of the M/H ratio




a=0.095 b=0.105 c=0.95 d=1.05 e =2.85 f=3.15

Fuzzy membership function for classifying Methane / Hydrogen ratio for the Roger 4-Ratio Method.

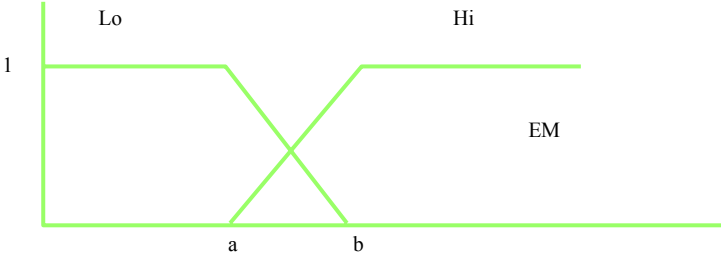
# Fuzzification the E/E ratio




a= 0.095 b=0.105 c= 2.85 d= 3.15

Fuzzy membership function for classifying Ethylene / Ethane ratio for the Roger 4-Ratio Method.

# Fuzzification of the E/M Ratio




a= 0.95 b=1.05

Fuzzy membership function for classifying Ethane / Methane ratio for the Roger 4-Ratio Method.

# Fuzzy Inference

**The fuzzy inference consists of two components which are antecedents (if part) and consequent (then part).**

*If MH=M and AE=M and EE=L and EM=H then Condition K - rules1*
*If MH=H and AE=M and EE=L and EM=L then Condition K - rules 2*
*….*
*If MH=VH and AE=L and EE=H and EM=L then Condition P- rules n*

*Antecedents:*

*Rule 1 = Min{ MH=M,AE=M,EE=L, EM=H}*
*Rule 2 = Min{ MH=H,AE=M,EE=L, EM=L}*
*.*
*Rule n = Min{ MH=VH,AE=L,EE=H, EM=L}*

*Consequent:*

*Condition K = Max (rule 1, rule 2}*
*Condition N = Max (rule r, rule p,…..rule n}*

# Example of Interpretation

*Roger's Ratio :*

*ConF to the degree of 0.11*
*ConG to the degree of 0.09*
*ConK to the degree of 0.8 ←Fired*

*Intepretation :*
*THE TRANSFORMER IS MOST PROBABLY IN COINCIDENTAL THERMAL HOTSPOT AND LOW ENERGY DISCHARGE*

*THE TRANSFORMER HAS A SLIM CHANCE BELONGS TO LOW ENERGY DISCHARGE: CONTINUOUS SPARKING TO FLOATING POTENTIAL*

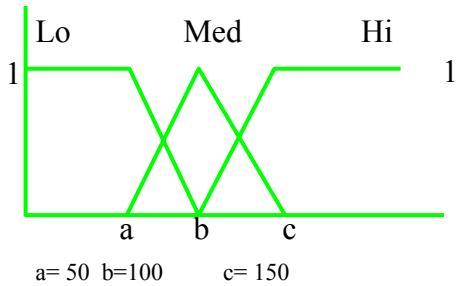
*THE TRANSFORMER HAS A SLIM CHANCE BELONGS TO LOW ENERGY DISCHARGE : FLASHOVER WITHOUT POWER FOLLOW THROUGH*

# Fuzzy Key Gas

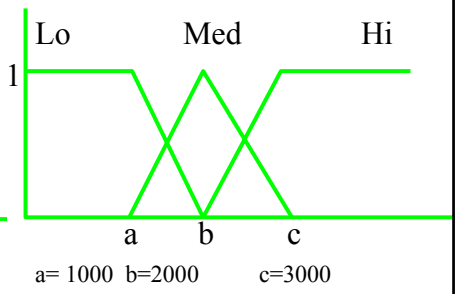
- **Uses the individual gases rather than calculation gas ratios for detecting fault conditions**

| Gases | Faults |
|---|---|
| • $H_2$ | Corona |
| • $CO$ & $CO_2$ breakdown | Cellulose insulation |
| • $CH_4$ & $C_2H_6$ | Low temperature oil breakdown |
| • $C_2H_4$ | High temperature oil breakdown |
| • $C_2H_2$ | Arcing |

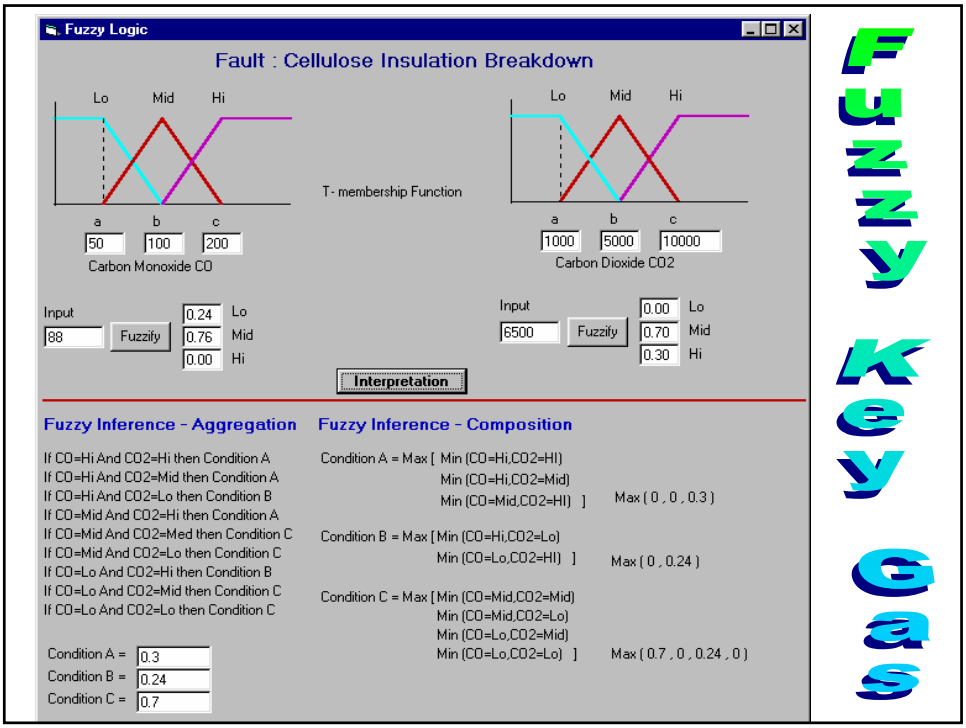
# Fuzzy Key Gas - CIB




Fuzzy membership functions for Carbon Monoxide




Fuzzy membership functions for Carbon Dioxide




# Fuzzy Key Gas - output

- 3 outputs will be determined for all the 5-fault type which are Critical, Cautious and Normal.
  - Critical - **the transformer has the specific fault type and immediate action must be taken to solve the problem**
  - Cautious - **the transformer may have the specific fault and should be monitored more frequently**
  - Normal - Healthy Condition

# CASE STUDY

## Interpretation from TNB Engineers

- . . . . . (cont)
  - MOISTURE CONTENT
- **Moisture Content / ppm** **Nil**
-
- TOTAL ACIDITY
- **Total Acidity / (mg KOH/g sample)** **Nil**
-

CONDITION ASSESSMENT

- DGA: Ethylene gas level is slightly high. Recommend resample of oil in 2 months for retest.

Moisture: Nil

- Acidity: Nil

## Example of ADAPT Interpretations

- ADAPT INTERPRETATION
- *<< MAIN INTERPRETATION >>*
-
- *TDCG Level Summary: Gases Over Limit Value:*

Current TDCG= 461 ppm Current C2H4 = 134 ppm

- Previous TDCG = 0 ppm Previous C2H4 = 0 ppm
- Sampling Duration = 0 days
- TDCG Rate = 0 ppm/day
- Gas In Ft3 = 0 ft3/day
- TCGv = 0 ppm
-
- *Fluid Quality:* *Summary of Diagnosis:*
- None High Temperature Oil Breakdown - 100%
- *Advices :*
- - This is the first test record. Recommend oil resampling interval= 6 months

## Supportive Interpretations from ADAPT

- *<< SUPPORTIVE INTERPRETATION S>>*
- 
- *Fuzzy Rogers Ratio Method:*
- The transformer is most probably in Thermal Fault of High Temp.Range 300-700 Degree Celsius:Bad Contacts/Joints(pyrolytic carbon formation) - 76.67%
- 
- *Fuzzy Key Gases Method:*
- The transformer is in critical condition of fault : High Temperature Oil Breakdown - 100%
- 
- *Logarithmic Nomograph Method:*
- Heating

## Conclusion to the research work

- The expected output of this project is a fully automated intelligent diagnostic software for diagnosing the power transformer fault.
- The technique of fuzzy logic has helps to overcome difficulties in setting boundary conditions of the gas-ratios and also allow the rules to be configured in a more natural language-type of structure which provide convenient and user-friendly usage.
- Artificial Intelligent techniques such as fuzzy logic/neural networks/data mining/etc are implemented for early fault detection in the transformers and thus lessen the risk of serious damage in the future.

## [5] Examples of research at the university

- 5.1: Differences among Postgraduate and Undergraduate Research
- 5.2: Example of a PhD Research Work
- 5.3: Example of a Masters Research Work
- 5.4: Example of a Bachelor's Research/Project
- 5.5: Preparations for an undergraduate final year project

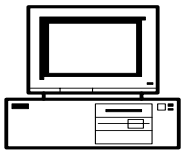
## *FUZZY CONTROL OF AN INVERTED ROTARY PENDULUM*

### Main objective

- To design a Fuzzy Logic Controller to balance the inverted pendulum at a specific orientation within a limited range.

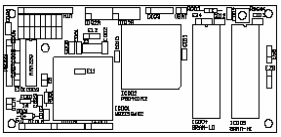
- To control and stabilize the rotary inverted pendulum using fuzzy logic control through:
  - ✉ software simulation (Visual Basic 5.0) and
  - ✉ real-time control on hardware via PC-based using DOS platform (Borland C++ 5.02 as editor and iC-96 as compiler)

# *SOFTWARE REQUIREMENTS*

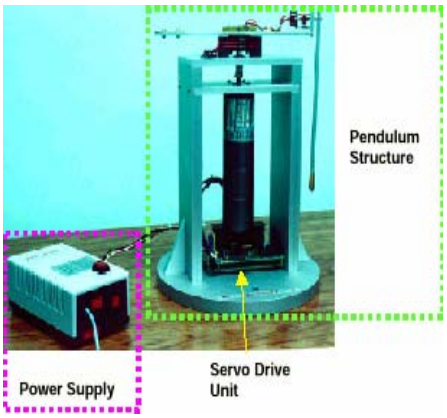


- Visual Basic 5.0
- Borland C++ 5.02
- iC-96 Compiler V2.3
- MCS-96 Relocator and Linker V2.4
- iECM-96 V2.3
- Fuzzy Output weights offline self-tuning program

# *HARDWARE REQUIREMENTS*



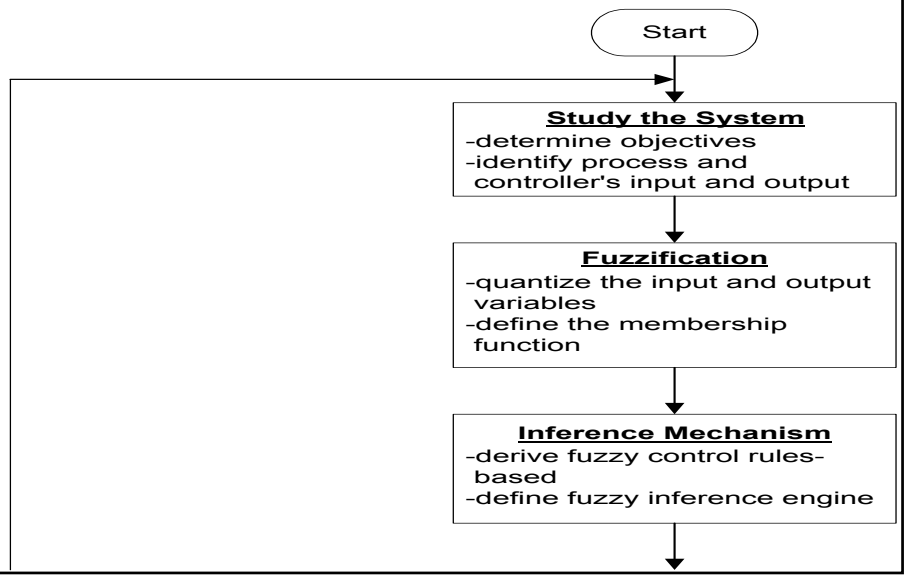
- The Micro-controller board UC96-SD version 2.0
- *KRi* Inverted pendulum model PP-300
  - rotary inverted pendulum structure
  - servo drive unit
  - power supply

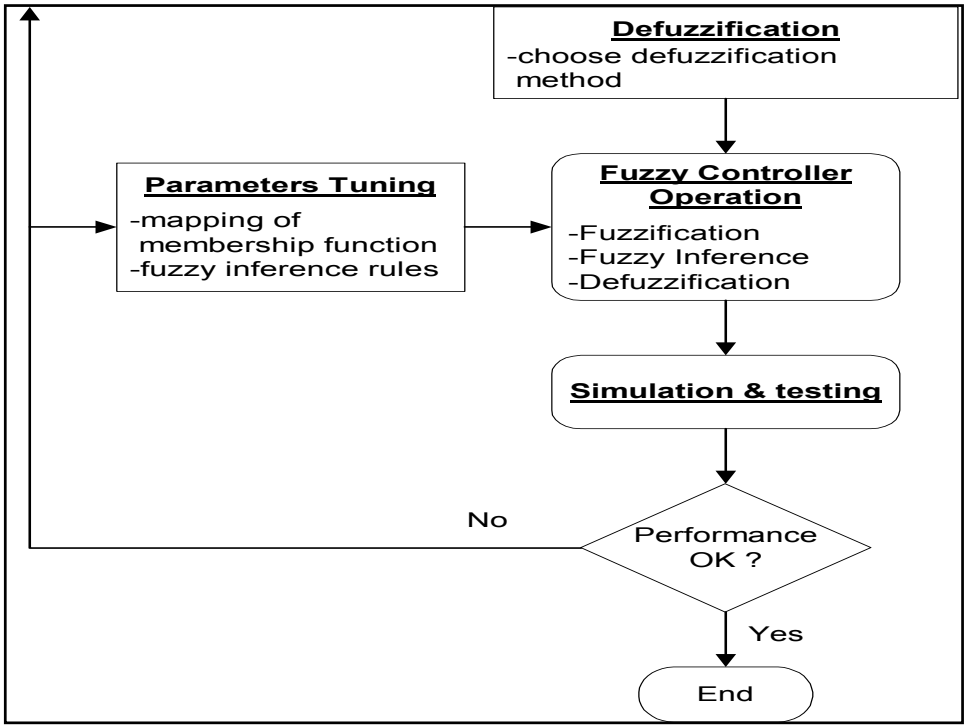


# Knowledge required

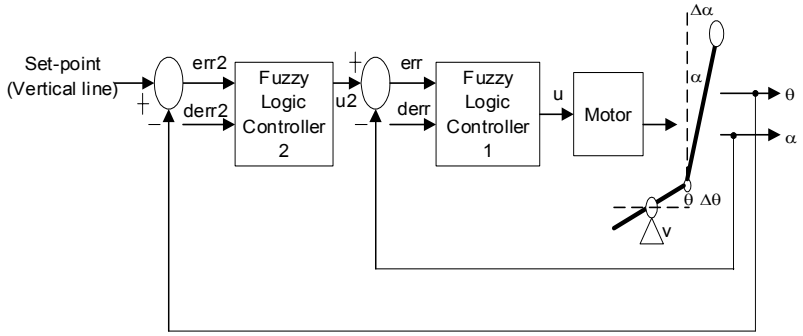
- Scope of work/project
- Whether viable to use fuzzy logic control
- Variables that can be measured
- Type of actuators
- Sensors to be used
- PC operating environment
- High/Low level programming languages
- Hardware knowledge of microchips
- Development systems of microchips
- Knowledge regarding the process
- Digital control theory
- Electronics/ Digital electronics
- Fuzzy logic control theory
- Others

# FUZZY LOGIC CONTROL SYSTEM DESIGN METHODOLOGY






# *FUZZY LOGIC CONTROL SYSTEM BLOCK DIAGRAM*




Input: 1) Angle between pendulum shaft and vertical line, $\alpha$
2) Angular Velocity of pendulum shaft, $\Delta\alpha$
3) Angle between motor arm and horizontal line, $\theta$
4) Angular Velocity of motor arm, $\Delta\theta$

Output: 1) Motor PWM, u

# *DYNAMIC EQUATIONS OF THE INVERTED PENDULUM*

$$\begin{bmatrix} J_o + m_1\left(L_o^2 + \lambda_1^2 \sin^2\theta_1\right) & m_1\lambda_1 L_o \cos\theta_1 \\ m_1\lambda_1 L_0 \cos\theta_1 & J_1 + m_1\lambda_1^2 \end{bmatrix} \begin{bmatrix} \ddot{\theta}_o \\ \ddot{\theta}_1 \end{bmatrix} +$$

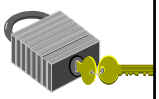
$$\begin{bmatrix} C_o + \frac{1}{2} m_1\lambda_1^2 \sin 2\theta_1\dot{\theta}_1 & -m_1\lambda_1 L_o \sin\theta_1 + \frac{1}{2} m_1\lambda_1^2 \sin 2\theta_1\dot{\theta}_1 \\ -\frac{1}{2} m_1\lambda_1^2 \sin 2\theta_1\dot{\theta}_o & C_1 \end{bmatrix} \begin{bmatrix} \dot{\theta}_o \\ \dot{\theta}_1 \end{bmatrix} +$$

$$\begin{bmatrix} 0 \\ -m_1\lambda_1 g_1 \sin\theta_1 \end{bmatrix} = \begin{bmatrix} \tau \\ 0 \end{bmatrix}$$

$$\begin{bmatrix} \dot{\theta}_o \\ \ddot{\theta}_o \\ \dot{\theta}_1 \\ \ddot{\theta}_1 \end{bmatrix} = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & \frac{de - bg}{bc - ad} & \frac{-bi}{bc - ad} & \frac{df - bd}{bc - ad} \\ 0 & 0 & 0 & 1 \\ 0 & \frac{ag - ce}{bc - ad} & \frac{ai}{bc - ad} & \frac{ah - cf}{bc - ad} \end{bmatrix} \begin{bmatrix} \theta_o \\ \dot{\theta}_o \\ \theta_1 \\ \dot{\theta}_1 \end{bmatrix} + \begin{bmatrix} 0 \\ \frac{-dg^*}{bc - ad} \\ 0 \\ \frac{cg^*}{bc - ad} \end{bmatrix} \underset{\sim}{u}$$

$$y = \begin{bmatrix} 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} \theta_o \\ \dot{\theta}_o \\ \theta_1 \\ \dot{\theta}_1 \end{bmatrix}$$

# *REAL TIME FUZZY LOGIC CONTROLLER DESCRIPTION*



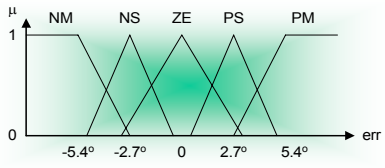
- Singleton fuzzy output is chosen due to its faster processing speed

$$Z^* = \frac{\sum_{t=1}^{n} B_n K_n}{\sum_{t=1}^{n} B_n}$$

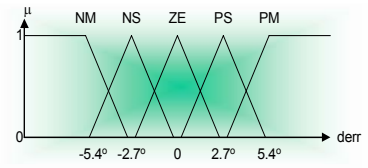
- **$B_n$ = the weight of the rule which is fired**
- **$K_n$ = singleton output value for that specific rule**

# INPUT MEMBERSHIP FUNCTIONS

- Input membership functions for both controllers are similar
- Single tone controller does not have output membership function




First Input Membership Function




Second Input Membership Function

# *FUZZY CONTROL RULES*

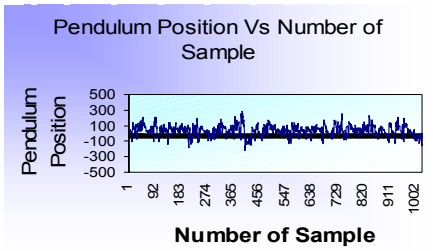
| err \ derr | NM | NS | ZE | PS | PM |
|---|---|---|---|---|---|
| NM | 855 | 837 | 804 | 346 | 0 |
| NS | 694 | 316 | 281 | 0 | -290 |
| ZE | 641 | 271 | 0 | -288 | -600 |
| PS | 259 | 0 | -284 | -272 | -713 |
| PM | 0 | -324 | -763 | -796 | -852 |

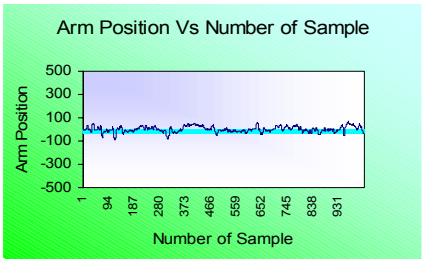
**First Fuzzy Controller**

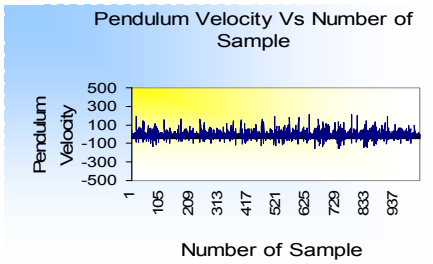
| err \ derr | NM | NS | ZE | PS | PM |
|---|---|---|---|---|---|
| NM | -698 | -539 | -425 | -250 | -155 |
| NS | -74 | -94 | -72 | -233 | -477 |
| ZE | 47 | 43 | 12 | -41 | -52 |
| PS | 200 | 192 | 254 | 517 | 675 |
| PM | 226 | 243 | 259 | 396 | 699 |

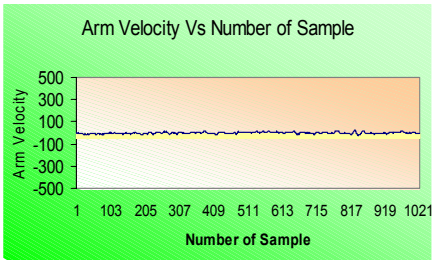
**Second Fuzzy Controller**

## *EXPERIMENTAL RESULT OF REAL TIME CONTROL*

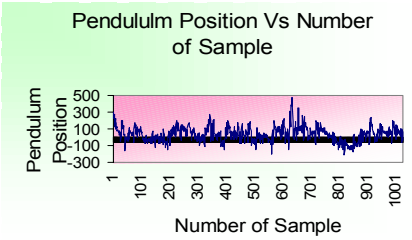


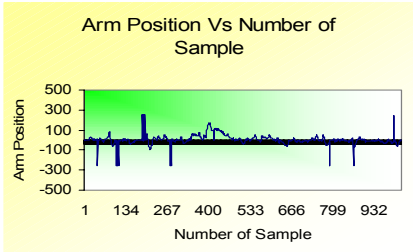



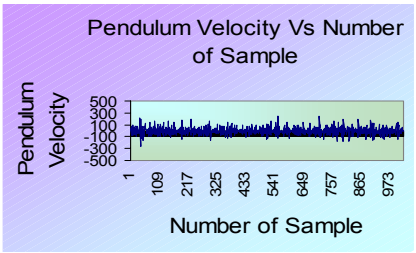



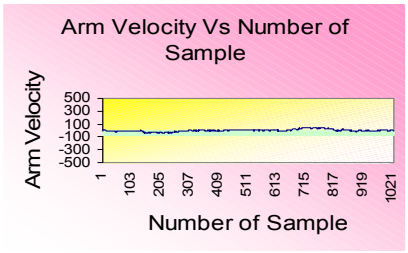




## *EXPERIMENTAL RESULT AFTER DISTURBANCE IS ADDED*



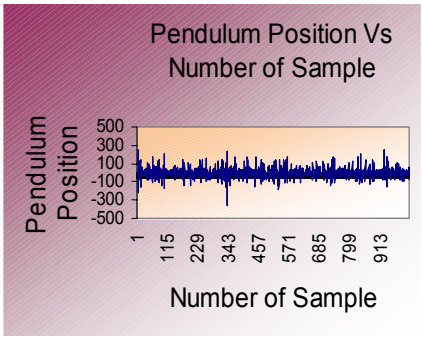



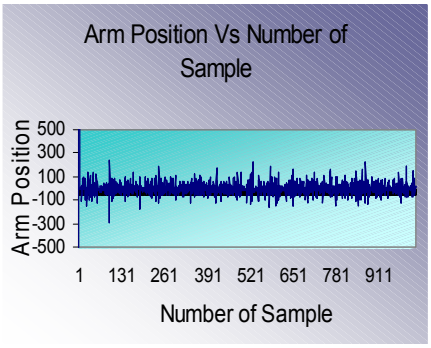



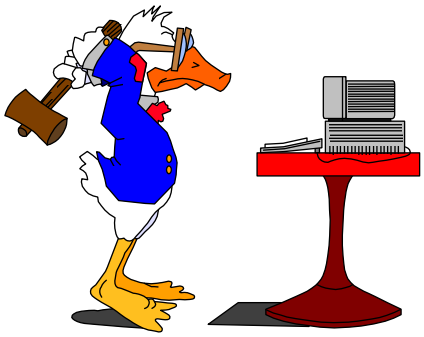



## *EXPERIMENTAL RESULTS WHEN SOME CONTROL RULES ARE TAKEN OUT*

- ***Both Controllers with only (3x3) rules, instead of (5x5) rules***



## *ANALYSIS OF RESULTS*

- **The research has shown the robustness of the fuzzy logic controller under disturbances and plant uncertainties**

## *Next project- coming up*

- Swing up the inverted pendulum and balance at a specific position
- Using neuro-fuzzy controller for better performance

## [5] Examples of research at the university

5.1: Differences among Postgraduate and Undergraduate Research

5.2: Example of a PhD Research Work

5.3: Example of a Masters Research Work

5.4: Example of a Bachelor's Research/Project

5.5: Preparations for an undergraduate final year project

a. Review of Literature

1. Include as much as needed to convince the reader that you have reviewed other studies.
2. Show the basis or need for your proposal study by presenting relevant literature.
3. For a larger study, use the literature to show the origin of your research questions and / or hypotheses.
4. Make the review a length appropriate to the proposal purpose and type : short for action research and longer for funding and thesis proposals.

b. Problem Statement

1. Make it brief and to the point
2. State the problem in such a way that it reveals to the reader why the study is being conducted.
3. State the problem in the form of a question.

c. Research Question and/or Hypotheses

1. State research questions concisely and limit their number to ten for most studies.
2. Ensure that the questions relate directly and logically to the problem statement.
3. Hypotheses should be stated when hunches are held.
4. Use the null hypothesis when statistical tests are to be made.
5. Ensure that hypotheses relate directly to research questions and the problem statement.

d. Method / Design
   1. Provide a brief description of the research method that will be used.
   2. Briefly describe your rationale for chosing this method.

e. Instrumentation
   1. List each instrument that will be used in the research study.
   2. Describe each instrument in terms of its form, purpose, validity and reliability.
   3. Identify the research question or hypothesis to which each instrument relates.
   4. If instruments will be developed as part of the study, describe what types of instruments will be developed and describe the procedures that will be used in development.

f. Data Collection Procedures

1. List the steps that will be taken to collect the data.
2. Indicate which instruments will be used with which group or sample.
3. With funding request proposals present enough detail so that the reader knows exactly what you plan to do.

g. Analysis Procedures

1. Describe how data collected in the previous component will be handled and summarized.
2. Identify the statistical techniques that will be utilized.
3. Show which statistical techniques will be used with which data and which hypotheses.
4. Describe how statistical results will be presented or reported.

h. Population and Sample

1. Identify the target populations of the study.
2. Describe the sample or samples that will be included in the research study.
3. Indicate the size of the sample to be chosen.
4. Identify strata or clusters that will be used in sampling.
5. Describe the sampling technique that will be used.

i. Research Personnel

1. Identify each individual who will be involved in conducting the research study.
2. Present a biographical sketch for each key person to be involved in the study.

j. Schedule

1. Present an indication of when the project will begin and end.
2. Present a timeline for each major activity or task of the study.

k. Resources

1. Identify any special resources that will be needed for the study such as facilities, equipment, etc.
2. Prepare a budget that identifies all financial needs of the study.

l. Appendix

1. Include any item that supports your proposal. This might include instruments, curriculum vitae, etc.

Have a Colleague Review and Evaluate your Completed Proposal.

Revise the Proposal Based on your Colleague's Reactions.

A 2-Day Course at GMI

# Research Methodology

## Module 4

## Writing Research Reports and Thesis and Writing Research Proposals

Prof. Marzuki B. Khalid
Director
Center for AI and Robotics
Universiti Teknologi Malaysia


## [6] Writing Research Reports and Thesis

- 6.1:Writing a research/project proposals?
- 6.2:Why the need to write papers and reports?
- 6.3:Writing a research report
- 6.4:Writing a technical paper
- 6.5:Contents of a thesis

# Writing a Research/Project Proposal

**I. Introduction**

A. The problem statement
B. A rationale for the research
   1. Statement of the research objectives
C. Hypothesis
D. Definitions of terms
E. Summary including a restatement of the problem

## *Writing a Research/Project Proposal*

**II. A (brief) review of the relevant literature**

A. The importance of the question being asked
B. The current status of the topic
C. The relationship between literature and problem statement
D. Summary including a restatement of the relationships between the important variables under consideration and how these relationships are important to the hypothesis proposed in the introduction.

## *Writing a Research/Project Proposal*

**III. Method**

A. Participants (including a description and selection procedures)
B. Research design
C. Data collection plans
   1. Operational definition of all variables
   2. Reliability and validity of instruments
   3. Results of pilot studies
D. Proposed analysis of the data
E. Results of the data

## *Writing a Research/Project Proposal*

**IV. Implications and limitations**
**V. Appendices**

A. Copies of instruments that will be used
B. Results of pilot studies (actual data)
C. Human experimentation approval
D. Participant permission form
E. Time line

## Criteria for Judging a Research Study
## *(for Lecturers/Reviewers)*

**The Review of Previous Research**

1. How closely is the literature reviewed in the study related to previous literature?
2. Is the review recent? Are there any outstanding references you know of that were left out?

**The Problem and Purpose**

3. Can you understand the statement of the problems?
4. Is the purpose of the study clearly stated?
5. Does the purpose seem to be tied to the literature that is reviewed?
6. Is the objective of the study clearly stated?
7. Is there a conceptual rationale to which the hypotheses are grounded?
8. Is there a rationale for why the study is an important one to do?

**The Hypothesis**

9. Are the research hypotheses clearly stated?
10. Are the research hypotheses explicitly stated?
11. Do the hypotheses state a clear association between variables?
12. Are the hypotheses grounded in theory or in a review and presentation of relevant literature?
13. Are the hypotheses testable?

**The Method**

14. Are both the independent and dependent variables clearly defined?
15. Are the definition and description of the variables complete?
16. Is it clear how the study was conducted?

**The Sample**

17. Was the sample selected in such a way that you think it is representative of the population?
18. Is it clear where the sample comes from and how it was selected?
19. How similar are the subjects in the study to those that have been used in other, similar studies?

**Results and Discussion**

20. Does the author relate the results to the review of literature?
21. Are the results related to the hypothesis?
22. Is the discussion of the results consistent with results?
23. Does the discussion provide closure to the initial hypothesis that the author presents?

**References**

24. Is the list of references current?
25. Are they consistent in their format?
26. Are the references complete?
27. Does the list of references reflect some of the most important reference sources in the field?
28. Does each reference cited in the body of the paper appear in the reference list?

**General Comments About the Report**

29. Is it clearly written and understandable?
30. Is the language biased (nonsexist and relatively culture-free)?
31. What are the strengths and weaknesses of the research?
32. What are the primary implications of the research?
33. What would you do to improve the research?

## Format for a Project Proposal

- Title
- Name of Student/Course
- Name of Supervisor(s)
- Duration
- Summary
- Keywords (Up to 5)
- Objectives
- Research/Project Outputs
- Introduction
- Methodology
- Key Milestones
- Expected Findings (Hypothesis)
- Research Schedule (Gantt Chart)
- References

## [6] Writing Research Reports and Thesis

6.1:Writing research/project proposals?

6.2:Why the need to write papers and reports?

6.3:Writing a research report

6.4:Writing a technical paper

6.5:Contents of a thesis

## Why the need to write research Reports/Papers/Thesis?

- It is obvious that every research needs good and proper documentation.
- To share research results with other researchers.
- To obtain some form of degree.
- To get views for improvement.
- To get recognition.
- For appraisal purposes.

## Quotations from a Vice-President of a Large Construction Company

*(Taken from "How Does Your Writing Measure Up…? by J. R. Gould, Chemical Eng. Journal)*

- "Every engineer has to write at some time or another".

- "Of course, all of us in our college days had visions of passing the writing job to our secretary, or even the office boy, but in reality it has turned out differently".

***Quotations from a Vice-President of a Large Construction Company***

- "Today the engineer is responsible for all kinds of communication jobs. Reports have to be turned in to government agencies, inter-company memoranda have to be written, and articles must be prepared for trade journals".
- "Also if the engineer wants to get ahead, he may find it necessary to deliver papers before professional societies".
- "Yet we often find ourselves unprepared to do the writing job".

[6] Writing Research Reports and Thesis

6.1:Writing research/project proposals?

6.2:Why the need to write papers and reports?

6.3:Writing a research report

6.4:Writing a technical paper

6.5:Contents of a thesis

- Research Reports are usually written at the end of a research work.
- It would not be too formal as that of a thesis or a technical paper. It could be an initial documentation for writing a technical paper for a journal or a conference.
- It is usually meant for internal verification/discussions or as a preliminary documentation for a bigger research.

## THE BODY OF A RESEARCH REPORT

- The body of the report follows the preliminary information. The body of the research report contains four logical divisions :

1. Introduction
2. Methodology
3. Presentation and Analysis of Data
4. Summary, Conclusions, and Recommendations.

## *THE BODY OF A RESEARCH REPORT*

**1. INTRODUCTION**

- Statement of the Problem
- Review of Related Literature
- Statement of Hypotheses of Research Questions
- Limitations
- Definition of Terms

## *THE BODY OF A RESEARCH REPORT*

**2. METHODOLOGY**

- Procedures for Collection and Treatment of Data

**3. PRESENTATION AND ANALYSIS OF DATA**

- Presentation of Data
- Analysis of Data

## *THE BODY OF A RESEARCH REPORT*

**4. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS**

- Summary
- Conclusions
- Recommendations

[6] Writing Research Reports and Thesis

6.1:Writing research/project proposals?

6.2:Why the need to write papers and reports?

6.3:Writing a research report

6.4:Writing a technical paper

6.5:Contents of a thesis

## The Body of a Technical Paper

1. Abstract – a short line regarding conclusion
2. Introduction
3. Description of system
   - Describe the new algorithm or approach
4. Simulation examples of algorithm
   - Real-time experiments
5. Discussion of Results
6. Conclusion
7. Acknowledgements
8. References
9. Appendix

## Checklist for Technical Article or Paper Preparation

1. Formulate idea for paper or article. Discuss with your supervisor and colleagues to determine if a paper should be written.

2. Search the literature to determine what has been written on the subject.

3. Write a comprehensive outline. A good outline reads like a table of contents.

## *Checklist for Technical Article or Paper Preparation*

4. Think the article through. Ask yourself if your outline will allow you to present the right amount of data in the best manner.

5. Gradually expand outline headings in-to sentences and paragraphs. Keep one idea to a paragraph.

6. Smooth transitions and expend on key words and ideas.

7. Rough out illustrations.

## *Checklist for Technical Article or Paper Preparation*

8. Write the rough draft, then see if you have answered these questions:

**Introduction**

- Did you properly orient the reader?
- Did you tell why the study (device, etc.) was needed?
- Why it is significant or unique?
- What problem did you solve ?
- Are the scope, limitations, and problems of the study well defined?
- Does the introduction generate enough interest in the reader for him to read the entire paper ?

## *Checklist for Technical Article or Paper Preparation*

**Body of Paper**

- Have you given necessary background material?
- Is it too much?
- Is the problem, concept, or system adequately and accurately cover the theory, test results, applications, methods of implementation?
- Did you make a point ?

**Conclusion**

- What was the original problem?
- How was it solved?
- Has a conclusion really been made ?

## *Checklist for Technical Article or Paper Preparation*

9. Revise the draft as required.
10. Have it typed double-spaces with at least one copy (or follow the journal's or conference's format).
11. Proofread manuscript carefully.
12. Review with you supervisor.
13. Submit.

## What a Manuscript (Technical Paper) Looks like

- Title Page
- Abstract
- Text including the Introduction, Method, Results and Discussion
- References
- Appendices
- Author Note
- Footnotes
- Tables
- Figure Captions
- Figures

## Title Page

- A running head for the publication
- The title of the manuscript
- A byline, or the authors listed in order of their contribution (and not necessarily alphabetical order) along with their institutional affiliation (for each author if different)

# *Example of a Title Page*

**TUNING OF A NEURO-FUZZY CONTROLLER BY GENETIC ALGORITHM**

Teo Lian Seng, Marzuki Khalid*, and Rubiyah Yusof

Centre for Artificial Intelligence and Robotics,
University Teknologi Malaysia,
Jalan Semarak, 54100 Kuala Lumpur, Malaysia.
Email address: marzuki@utmnet.utm.my
Tel: 03-26913710 Fax: 603-2697081 5
(All correspondence should be sent to *)

## The Abstract

- A one sentence statement of the purpose
- A description of the participants used in the research including the number, their age, gender, ethnicity, special conditions, and other identifying characteristics
- The results
- Any conclusions being offered

## *Example of an Abstract*

**ABSTRACT**

Due to their powerful optimization property, genetic algorithms (GAs) are currently being investigated for the development of adaptive or self-tuning fuzzy logic control systems. This paper presents a neuro-fuzzy logic controller (NFLC) where all of its parameters can be tuned simultaneously by GA. The structure of the controller is based on the Radial Basis Function neural network (RBF) with Gaussian membership functions. The NFLC tuned by GA can somewhat eliminate laborious design steps such as manual tuning of the membership functions and selection of the fuzzy rules. The GA implementation incorporates dynamic crossover and mutation probabilistic rates for faster convergence. A flexible position coding strategy of the NFLC parameters is also implemented to obtain near optimal solutions. The performance of the proposed controller is compared with a conventional fuzzy controller and a PID controller tuned by GA. Simulation results show that the proposed controller offers encouraging advantages and has better performance.

## The Text

- This would normally consist an Introduction section, followed by a section on the main algorithm that has been used such as the fuzzy theory, neural networks, etc.
- A good introduction orients the reader to the importance of the problem by providing a sufficient background material.
- This is not the place for an extensive historical review of the important literature.
- It should mention only the most important works that have been done and illuminate the importance studies.
- Basically, your goal is to provide the reader with sufficient information to understand and appreciate the importance and scope of the problem.

# *Example of the Text*

1. INTRODUCTION

Fuzzy logic control systems, which have the capability of transforming linguistic information and expert knowledge into control signals [1-2], are currently being used in a wide variety of engineering applications [3-7]. The simplicity of designing these fuzzy logic systems has been the main advantage of their successful implementation over traditional approaches such as optimal and adaptive control techniques. Despite the advantages of the conventional fuzzy logic controller ( FLC ) over traditional approaches, there remain a number of drawbacks in the design stages. Even though rules can be developed for many control applications, they need to be

2. DESCRIPTION OF THE NEURO-FUZZY CONTROLLER

This section discusses the formulation of the NFLC, which implements a simplified fuzzy logic control algorithm based on the radial basis function neural network [10,20,25]. The RBF neural network is usually used to approximate a continuous linear or nonlinear function mapping. Its structural and computational detail can be referred in [26, 27]. The structure of the multi-input

## Method

- This could be divided into several sections and sub-sections (if needed).
- The method section of the manuscript describes how the study was conducted.
- This information is reported in sufficient detail so that any one can refer to this section and duplicate the study exactly as it was originally done.

# *Example of the Method*

**3. DESIGN OF THE NEURO-FUZZY CONTROLLER BY GA**

**3.1 Genetic Algorithm**

Genetic Algorithm (GA) is a random search technique that imitates natural evolution with Darwinian survival of the fittest approach. GAs perform on the coding of the parameters and not on the exact parameters, therefore, it does not depend on the continuity of the parameter nor the existence of derivatives of the functions as needed in some conventional optimization algorithms.

**3.2 Tuning of the NFLC Parameters by GA**

This section discusses how the proposed NFLC is formulated by using the GA approach, where all the parameters of the NFLC are initially randomized, then being tuned and optimized simultaneously by GA.

**A. Coding strategy of the NFLC parameters**

In this paper, the NFLC as shown in Fig.1 is configured to have two inputs ($X_1$, $X_2$) and one output (y), which is the controlled variable. Each of the Gaussian membership functions has a center $C^i_{x_1}$ ($C^i_{x_2}$) and the width $D^i_{x_1}$ ($D^i_{x_2}$) for the inputs $X_1$ and $X_2$ respectively. In the following

## Results and Discussions

- Next in the next of the manuscript is the Results section where the reader can find what statistical techniques were used to analyze the data and what the result of the analysis were.
- [This is not the place for a presentation of the actual results of the analysis, but for only information about how the analysis was done.]
- This depends also on the type of paper.

# *Example of the Results*

**4. SIMULATION RESULTS**

**4.1 Application To An Unstable Plant**

In this application, consider a non-minimum phase plant having an open loop unstable pole with the following transfer function :

$$G_k(s) = \frac{(-0.67s^2 + 5.52s - 9.437)10}{(s - 0.559)(s^2 + 27.388s + 12.6244)} \quad (4.1)$$

The transfer function is discretized with a sampling period of 0.01 second. The discrete transfer function resulted in having two non-minimum zeros and one unstable pole.

# Results would normally discussed about the experiments

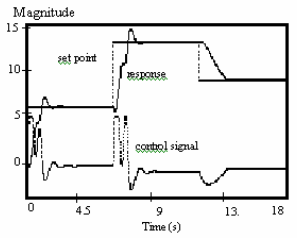



Fig.7 Response of the open-loop unstable with non-minimum phase plant using the GA tuned NFLC.

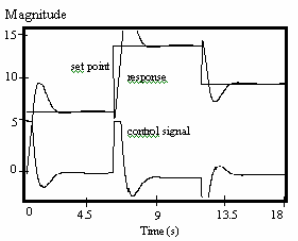



Fig.8 Response of the open-loop unstable with non-minimum phase plant using the GA tuned PID controller.

***Results and Discussions***

- The Discussion section is where the author of the manuscript is free to explore important relationships among what has been done in the past, the purpose of the study, the stated hypothesis, and the results of the current study.
- Now it is time for an evaluation of what has been done and a "measuring up" to see if the reported results fit the researcher's expectations.
- Most technical papers combined the Results and Discussion sections as in the paper we discussed (contrary to the point raised in the box).

## Conclusion

- This section sums up the whole paper.
- Here is an opportunity for the researcher to sum up the purpose and findings reported in the manuscript.
- It is here that you will find any statement as to what contribution might have been made by the current research and how well the original question was answered.
- This section could also be the place where the implications and limitations of the current study are discussed as are suggestions for future research.

# *Example of a Conclusion*

5. CONCLUSION

This paper has presented a neuro-fuzzy controller where all its parameters can be simultaneously tuned by GA. The controller is based on the Gaussian type RBF neural network. By appropriate coding of the NFLC parameters, it can achieve self-tuning properties from an initial random state. By employing dynamic crossover and mutation probability rates, the tuning process by GA was further improved. The proposed NFLC tuned by GA has also been tested on three different systems, i.e., an unstable and non-minimum phase plant, a non-linear plant, and in a automated car parking system. In the experiments, the control performance has been compared

## References

- The references are a list of sources that were consulted during the course of the research and the writing of the manuscript.
- References can be anything from a book to a personal communication, and all references have to be entered in the reference list in a particular format.
- The way the references are written in the text and also in the references section very much depend on the style/format of the journals or conferences.

## *Example of references in an IEEE journal*

applied to three different control systems. The proposed NFLC structure takes less parameters as compared to a conventional FLC [2] or the Takagi-Sugeno type of FLC [18]. This resulted in a shorter coded string which allows GA to search more efficiently.

The GA is implemented using dynamic crossover and mutation probability rates for better exploitation of the optimal NFLC parameters [23,24]. Furthermore, a flexible position

**References**


1. Zadeh L.A., Fuzzy Sets, *Information and Control*, Vol.8, pp338-353, June 1965.
2. Mamdani E.H. and Assilian S., An experiment in linguistic synthesis with a fuzzy logic controller, *Int. J. Man Mach. Studies*, Vol. 7, No. 1, pp1-13, 1975.
3. King P.J. and Mamdani E.H., The Application of Fuzzy Control System to Industrial Process., *Automatica*, Vol.13., pp235-242, 1977.
4. Qin S.H. and Borders G., A Multiregion Fuzzy Logic Controller of Nonlinear Process Control, *IEEE Transactions on Fuzzy Systems*, Vol 2, No 1, pp74-81, Feb.1994.


## Appendices

- An appendix usually contains information that is not essential for understanding the content of the manuscript but it is important for getting a through picture of what happened.
- Usually, an appendix will contain original data or drawings.

## Author Notes

- Author notes include any ancillary material that is important to understanding the content of the manuscript but does not belong in any of the previous sections.

## Footnotes

- Footnotes are used to elaborate upon references or some other technical point in the manuscript.

## Tables

- Tables are text arranged in columns or rows, and are most often used in the results section.

## Figure Captions

- A figure caption identifies each of the figures with a number and a title. A figure caption should have enough description of the figure you are presenting.

## Figures

- Here is where the actual figures for the manuscript are physically placed.
- Every figure must be explained in the text.

## [6] Writing Research Reports and Thesis



## Contents of a Thesis

- Abstract (1 page)
- Declaration
- Acknowledgments
- Table of Contents
- List of Symbols and Figures
- Chapter 1: Introduction
  - Background
  - Objectives of Thesis
  - Layout of Thesis
- Chapter 2: Theory on the Research

## Contents of a Thesis

- Chapter 3: Proposed Methodology
- Chapter 4: Implementation
- Chapter 5: Experimental Results and Discussions
- Chapter 6: Conclusions and Further Work
- References
- Appendices

## [7] Writing Research Proposals (for Grants Applications)

7.1: Why do we need to write research proposals?

7.2: Research Grants in Malaysia

7.3: How to write good research proposals?

7.4: Case Study


Some Information on CAIRO

- Set up on January 1st, 1997
- One of 30 Centres of Excellence in UTM
- One of the Most Active Research Centers in Malaysia
- Grants totalling RM4 million (US$1 million)
- We received a total of 14 IRPA Grants and 2 IGS Grants
- Involving Process Automation, Robotics and AI Applications

## Some Examples of CAIRO's Research Grants

**A. Geran IRPA (Kem. Sains, Teknologi dan Alam Sekitar)**

| Bil | Kod Geran | Tajuk Penyelidikan | Tempoh | Jumlah (RM) |
|---|---|---|---|---|
| 1. | 72093 | Intelligent Industrial Visual Inspection and Recognition System<br>Ketua : Prof. Marzuki Khalid | Nov 1996 – Dis 2001 | 123,000.00 |
| 2. | 72038 | Development of Intelligent Control Systems<br>Ketua : Prof. Marzuki Khalid | Nov 1996 – Dis 1999 | 180,000.00 |
| 3. | 72129 | Optimization of Process Plants using Artificial Intelligence Techniques<br>Ketua : Prof. Marzuki Khalid | Jul 1998 – Jun 2001 | 575,000.00 |
| 4. | 72121 | Automation and Application of Artificial Intelligent Techniques for Water Treatment Plants<br>Ketua : Prof. Marzuki Khalid | Jul 1998 – Jun 2001 | 247,000.00 |
| 5. | 72185 | Design and Development of an Automated Data Entry System<br>Ketua : Prof. Marzuki Khalid | Sep 1999 – Sep 2001 | 192,850.00 |
| 6. | 72234 | Development of an Intelligent Power Transformer Fault Diagnosis and Prediction System<br>Ketua : Prof. Marzuki Khalid | Sep 1999 – Sep 2001 | 401,375.00 |
| 7. | 72305 | Intelligent Traffic Lights System<br>Ketua : Prof. Madya Rubiyah Yusof | Nov 1999 – Dis 2001 | 115,000.00 |
| 8. | 72284 | Intelligent Database and Data Mining<br>Ketua : Prof. Madya Rubiyah Yusof | Nov 1999 – Dis 2001 | 115,000.00 |
| 9. | 72048 | Development of Wall Climbing Robot for High Rise Buildings<br>Ketua : Prof. Shamsudin Mohd Amin | Apr 1996 – Dis 1999 | 621,000.00 |
| 10. | 72147 | Development of Internet Based Telerobotics | Sep 1999 – | 265,000.00 |

## [7] Writing Research Proposals (for Grants Applications)

- 7.1: Why do we need to write research proposals (for grants)?
- 7.2: Research Grants in Malaysia
- 7.3: How to write good research proposals?
- 7.4: Case Study

## Why do we need to write Good Research Proposals?

- Good research proposals will lead to successful research grants.
- Academicians need research grants to carry out their research.
- Research grants will help to pay for research officers/assistants, research equipment, accessories, attend conferences, etc.
- Good research will lead to good publications, recognition and appraisals.

## Factors affecting writing good research proposals?

- Scope does not reflect research theme
- Objectives – not clear
- Project Outputs- not clear
- Research methodology – not clear
- Unreasonable budget
- Hasty – in a hurry to finish proposal
- Deadlines too near
- Does not meet national /sectoral objectives
- Often research team do not meet and discuss

## Factors affecting getting successful research grants!

- Following the scope of the research theme
- Good research proposals
- Reputation
- Research Leader/ Team
- Unreasonable budget
- Evaluation Panel

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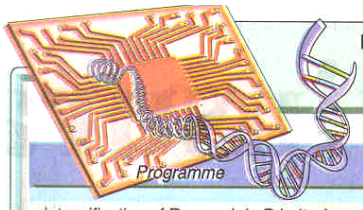
## Available Grants for UTM Academicians

- IRPA (MOSTE) – ~ 85% of the time
- RMC Short Term Grant (UTM) – ~10%
- IGS (MOSTE) – ~5%
- Contract Research from Companies (TNB, Guthrie, etc.)
- MGS (MDC)
- DAGS (MIMOS)
- CRDF (MTDC)
- FELDA Grant (FELDA)
- Overseas Grants (EU, Japan, etc.)

~5%

## Approved RM8 Research Grants



**DEVELOPMENT ALLOCATION FOR SCIENCE AND TECHNOLOGY, 1996-2005 (RM million)**

| Programme | 7MP | | 8MP |
|---|---|---|---|
| | *Allocation* | *Expenditure* | *Allocation* |
| Intensification of Research in Priority Areas (IRPA) | 755.0 | 718.1 | 1,000.0 |
| Malaysia-MIT Biotechnology Partnership Programme | 35.0 | 33.3 | – |
| Technology Development for SMIs | 58.0 | 41.2 | 30.0 |
| Technology Acquisition Fund (TAF) | 118.0 | 118.0 | 250.0 |
| Commercialisation of Technology | 208.0 | 203.9 | 610.0 |
| *Industrial Research and Development Grant Scheme (IGS)* | *50.0* | *45.9* | *200.0* |
| *MSC Research and Development Grant Scheme (MGS)* | *65.0* | *65.0* | *200.0* |
| *Demonstrator Applications Grant Scheme (DAGS)* | *30.0* | *30.0* | *100.0* |
| *Commercialization of Research and Development Fund (CRDF)* | *63.0* | *63.0* | *110.0* |
| S&T Infrastructure and Development | 2,413.3 | 1,496.7 | 2,818.9 |
| **Total** | **3,587.3** | **2,611.2** | **4,708.9** |

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How to write Research Proposals?

What are the contents of a Research Proposal?

- Most research proposals already have a format.
- Let's see the IRPA Research Proposal Format

# The IRPA Research Grant

(Application Format)

## IRPA Research Proposal Format [1]

- Project number – [Given by RMC]
- Project title
- Project leader
- Organisation
- Key words
- Specific objectives of project
- Research background of project
  - Project status (new, modification, or extension)
  - Literature review summary
  - Related research

## IRPA Research Proposal Format [2]

- Type of research
  - Scientific research (fundamental research)
  - Technology development (applied research)
  - Product/process development (design end engineering)
  - Social/policy research
- Socio-economic objective
- Target Area, Research Theme, Programme
- Fields of research

# IRPA Research Proposal Format [3]

- Direct customers/beneficiaries of the project
- Outputs expected from the project
- Technology transfer/diffusion approach
- Organisational outcomes expected
- Sectoral/national impacts expected

# IRPA Research Proposal Format [4]

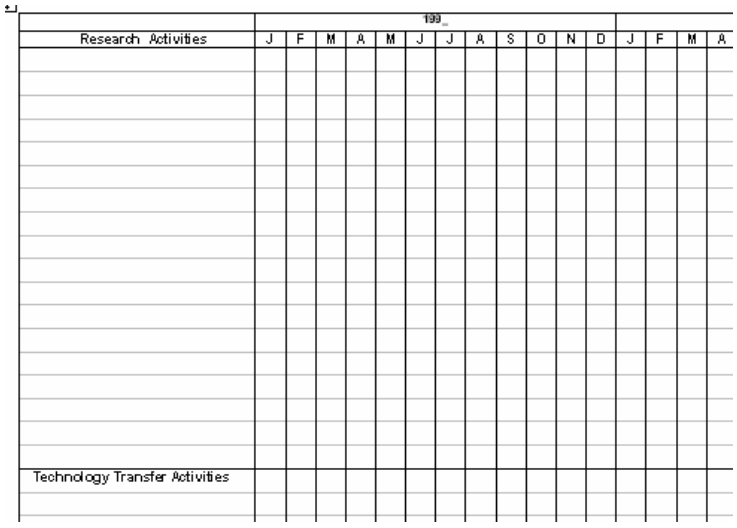
| C. Project Team | | | |
|---|---|---|---|
| **Name**[1] | | **Organisation** | **Man-months**[2] **on project** |
| **Project Leader** (Please provide name) | | | |
| **Programme Head** (Please provide name) | | | |
| **Researchers** (Please provide names or numbers of researchers) | | | |
| **Support Staff** (Please indicate how many) | | | |
| **Contract Staff** (Please indicate how many) | | | |
| | | | |
| | | **Total** | |

# IRPA Research Proposal Format [5]

- Research organisations involved in the project
- Industry linkages
- Research methodology
- Project activities
- Key milestones
- Risks of the project
- Duration

# IRPA Research Proposal Format [6]

- Project Schedule (Gantt Chart)



# IRPA Research Proposal Format [7]

- Project Costs

A. **Staff costs** (Please include the yearly staff costs of the project. For computation, use the Staff Cost Estimation Form in Appendix D. Numbers in parentheses refer to expense codes)

| Staff Category | Total RM | 200_ RM | 200_ RM | 200_ RM |
|---|---|---|---|---|
| • Salaried personnel (11100)<br>• Temporary and contract personnel (J 400) | | | | |
| Sub-total staff costs | | | | |

# IRPA Research Proposal Format [8]

- Project Costs (Continued)

B. **Direct project expenses** (Please include the yearly direct expenses of the project. For computation, use the Direct Expenses Estimation Form in Appendix E. Numbers in parentheses refer to expense codes)

| Expense Category | Total RM | 200_ RM | 200_ RM | 200_ RM |
|---|---|---|---|---|
| • Travel and transportation (J 500)<br>• Rentals (J 600)<br>• Research materials and supplies (J 700)<br>• Minor modifications and repairs (J 800)<br>• Special services (J 900)<br>• Special equipment and accessories (J 1000) | | | | |
| Sub-total direct expenses | | | | |

# IRPA Research Proposal Format [9]

- Project Funding

A. Funding sources (Please indicate funding sources for the project; see list of funding sources in the Guidelines)

| Funding Sources | RM | % of Total Funding |
|---|---|---|
| - IRPA Grant | | |
| - Internal Funds | | |
| - Other Sources (please specify) | | |
| **Total** | | 100% |

# IRPA Research Proposal Format [10]

- Project Funding (Continued)

B. Disbursement schedule for IRPA funds, by participating research organisation (Please indicate how IRPA funding for the project will be allocated)

| Organisation | Total RM | 200_ RM | 200_ RM | 200_ RM |
|---|---|---|---|---|
| | | | | |
| Total IRPA Grant | | | | |

# IRPA Research Proposal Format [11]

| | |
|---|---|
| **A.** | **Contractual obligations under this project** (Please indicate any contractual obligations with third parties that will be entered in for this project) |
| **B.** | **Ownership of intellectual property rights** (Please indicate the organisation(s) that will own the intellectual property rights that may arise from this project) |
| **C.** | **Approving Officer** (of the organisation in which the Project Leader is based) |

| | | | | | |
|---|---|---|---|---|---|
| Name | : | | | | |
| Designation | : | | | | |
| Date | : | | Signature | : | |

# IRPA Research Proposal Format [11]

- Appendix A- CV
- Appendix B- Institutional Background
  (Given by RMC)
- Appendix C- Summary of Past Research Projects

# IRPA Research Proposal Format [12]

## Appendix D: Staff Cost Estimation Worksheet

| Role in Project | Total | Project Leader | Researchers | Support Staff | Contract Staff |
|---|---|---|---|---|---|
| Daily Rate (RM) | | | | | |
| Research Activities | | | Man-Days[1] | | |
| | | | | | |
| Total Year 1 (200_) Man-days | | | | | |
| Total Year 1 (200_) Cost (RM)[2] | | | | | |
| | | (11100) | (11100) | (11100) | (J 400) |
| | | | | | |
| Total Year 2 (200_) Man-days | | | | | |
| Total Year 2 (200_) Cost (RM)[2] | | | | | |
| | | (11100) | (11100) | (11100) | (J 400) |
| | | | | | |
| Total Year 3 (199_) Man-days | | | | | |
| Total Year 3 (199_) Cost (RM)[2] | | | | | |
| | | (11100) | (11100) | (11100) | (J 400) |
| Total Project Man-days | | | | | |
| Total Project Staff Cost (RM) | | | | | |
| | | (11100) | (11100) | (11100) | (J 400) |
| Total Man-months[3] | | | | | |

# IRPA Research Proposal Format [13]

## Appendix E: Direct Expenses Estimation Worksheet

| Expense Categories and Items | Total RM | 200_ RM | 200_ RM | 200_ RM |
|---|---|---|---|---|
| Travel and transportation (J 500) | | | | |
| | | | | |
| Rentals (J 600) | | | | |
| | | | | |
| Research materials and supplies (J 700) | | | | |
| | | | | |
| Minor modifications and repairs (J 800) | | | | |
| | | | | |
| Special services (J 900) | | | | |
| | | | | |
| Special equipment, accessories* (J 1000) | | | | |
| | | | | |
| Total direct expenses | | | | |

## SUMMARY OF THIS MODULE

- Writing Research Reports and Thesis
  - Research/project proposals
  - Judgment on a project proposal
  - Research report
  - Writing a technical paper
  - Contents of a thesis
- Writing Research Proposals (for Grants Applications)
  - Why do we need to write research proposals?
  - How to write good research proposals?
  - Case Study

## Have the course objectives been met?:

- understand some basic concepts of research and its methodologies
- identify appropriate research topics
- select and define appropriate research problem and parameters
- prepare a project proposal (to undertake a project)
- organize and conduct research (advanced project) in a more appropriate manner
- write a research report and thesis
- write a research proposal (grants)